Appendix 3.2-A

Basis of Design Report

Basis of Design Report

Oroville Wildlife Area Flood Stage Reduction Project

Sutter Butte Flood Control Agency

65% Submittal

February 1, 2016

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1 Project Background

The Sutter Butte Flood Control Agency (SBFCA) is the project sponsor responsible for improving flood protection along the Feather River corridor. As part of this goal, SBFCA is intending to implement the Oroville Wildlife Area Flood Stage Reduction (OWA FSR) Project. The OWA FSR Project consists of weir improvements and associated ecosystem restoration in order to improve the connectivity of the Feather River to its historic floodway and reduce stages within the main channel.

Currently, when high flows occur in the Feather River, water is diverted into the OWA D-Unit where it flows through a number of waterways before re-entering the Feather River at the southern end of the D-Unit. This occurs via a system of inlet and outlet weirs located between the Feather River and the OWA D-Unit. The OWA essentially acts as a flood control detention basin in order to reduce peak stages in the main channel.

The current system of weirs does not function as designed or intended. According to California Department of Water Resources (DWR) Oroville Field Division staff, the intent of the original design was to divert approximately 80,000 cubic feet per second (cfs) from the Feather River into the OWA during a 200-year event. However, preliminary modeling results show that the existing inlet weir diverts approximately 40,000 cfs during the 200-year event. This deficiency in the weir system contributes to higher stages in the Feather River, which directly results in increased flood threats throughout the Feather River system.

The capacity of the weir system has been impacted by historic floods that have repeatedly washed out the inlet and outlet weirs requiring regular post-flood maintenance work to be performed by Oroville Field Division staff. Flood damage has now resulted in post-flood repairs exceeding the scope of regular maintenance work. The OWA FSR Project intends to restore the flood reduction capacity of the D-Unit by repairing and improving the inlet and outlet weirs. The Project will also include public recreation improvements within the D-Unit.

This Basis of Design Report (BODR) provides the technical basis for the 65% design plans and specifications for the OWA FSR Project. This report presents the project design requirements, criteria, guidance, assumptions, calculations, and coordination related to the design. It also serves to document the issues that were encountered during the design process and the manner in which these issues were resolved.

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2 Site Description

2.1 Project Area

The OWA comprises approximately 11,850 acres divided into 8 sections named Units A through H. The D-Unit is located just west of Highway 70, and across the river from the Thermalito Afterbay outlet. The D-Unit is approximately 1,500 acres and defines the OWA FSR Project boundary. The OWA is owned by DWR and is managed by the California Department of Fish and Wildlife (CDFW). A location map is provided in Figure 1.

2.2 Construction History

The OWA D-Unit was heavily mined during the California gold rush era which left several excavations and dredge tailings piles in place. The area was transformed into its current condition during construction of the Oroville Dam in 1961. During this period, the northern and western dikes were constructed to reclaim land within the OWA D-Unit which had been identified as a source of pervious borrow for the dam. Borrow operations left the current system of interior canals and ponds in place. This includes a sheetpile outlet weir on the western dike and a low flow culvert outlet in the southwest corner of the D-Unit. The existing inlet gabion weir at the northeast corner of the D-Unit was constructed in 1999 following dike failures during the 1997 flood.

2.3 Flood History

Major floods have disturbed the project area since construction of the Oroville Dam. Several of these floods resulted in breaches of the dikes surrounding the D-Unit. A summary of flood damage issues is as follows:

- 1986: Floods breached portions of the northern dike.
- 1995: The northern dike was breached at the location of the existing inlet weir. Breaches also occurred along Fish Weir Rd and at the dike just upstream of Robinson’s Pond. The dike upstream of Robinson’s Pond was not repaired following the breach.
- 1997: Two breaches occurred this year, one located at Fish Weir Road and one along the northern D-Unit dike near the location of the existing inlet weir.
- 2006: The existing gabion weir spilled over for the first time and the dike at Fish Weir Road was breached again.

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3 Pertinent Data

Table 1 below provides a summary of the relevant reports and design data that were utilized during development of the 65% plans and specifications.

Table 1. Summary of Data Types and Sources

Data Type	Source	Date
Photographs of site	Site Visit	2015
Topography (LiDAR)	DWR	2010
Topography (Ground Survey)	Wood Rodgers	2015
Oroville Wildlife Area Flood Stage Reduction Project, Hydraulic Analysis – Baseline Model Documentation	PBI	August 18, 2015
Oroville Wildlife Area Flood Stage Reduction Project, Conceptual Alternatives Analysis Report	PBI	August 24, 2015
Culvert Sizing for Proposed Road Crossing in the Oroville Wildlife Area D-Unit Technical Memorandum	PBI	September 17, 2015
Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Analysis for With-Project Conditions Technical Memorandum	PBI	December 15, 2015
Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Information Request for Inflow Weir Design	PBI	January 27, 2016
Riprap Design for Sites 2, 5, and 9 Technical Memorandum	HDR	February 1, 2016
Portable Toilet Foundation Slab Design Technical Memorandum	HDR	January 25, 2016
Oroville Wildlife Area Flood Stage Reduction Project, Geotechnical Investigation and Recommendations Technical Memorandum	HDR	January 28, 2016
Levee Repair Drawings (Existing Gabion Weir)	DWR Oroville Field Division	July 1, 1998
1975 – Clean Water Project, Schedule B Gravity Sewer and Outfall Construction Drawings	Sewerage Commission, Oroville Region and CH2MHill	September 20, 1974

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4 Project Description

The overall OWA FSR Project consists of flood control improvements, ecosystem restoration, and recreation features. The ecosystem restoration and some recreation features are not a part of these design documents.

4.1 Flood Control Improvements

Flood control improvements include weir construction to improve the connectivity of the Feather River to its historic floodplain and reduce 200-year flood stages within the Feather River. The existing weir system includes one 600-foot-wide primary inlet weir and one 550-foot-wide primary sheet pile wall outlet weir. There is also an existing low flow outlet and culvert located at the southwest corner of the OWA D-Unit. Flood control improvements will consist of the following:

- A new gabion inlet weir will be constructed along the northern dike approximately 1,000 feet west of the existing weir. The weir crest elevation will be elevation 130.0 North American Vertical Datum of 1988 (NAVD88) and the weir opening will be 400-feet-wide. The weir will be armored with an 18-inch-thick gabion mattress over the top and landside slope of the weir and 3-feet-by-3-feet gabion baskets at the slope transition points. The gabion mattress will extend 60-feet beyond the weir crest and landside to address potential erosion.
- Rock slope protection will be placed on the north and south sides of the existing sheetpile wall outlet weir and at the north side of the adjacent access road. The adjacent access road will have a hardened concrete road surface.
- The 60-inch corrugated metal pipe (CMP) culvert at the low flow outlet along the western dike will be removed. Three new temporary 72-inch CMP culverts will be placed.
- The 60-inch CMP outlet and berm south of the Pit No. 2 pond will be removed. A hardened concrete road surface will be constructed flush with the outlet channel to allow water to freely flow from the pond into the channel during high flow events.

4.2 Recreation Features

The OWA D-Unit offers multiple recreational activities such as hunting, fishing, wildlife viewing and nature study. The recreation component of the OWA FSR will consist of the following:

- A public parking area with a new concrete pad for portable restroom facilities will be constructed at the northwest corner of D-Unit.
- A combined recreational and emergency vehicle access ramp will be constructed over an interior ditch at the west side of the D-Unit. The ramp will be an earthen embankment with a 24-inch culvert placed underneath it to maintain low flow within the ditch.
- New ramps to allow river access for kayaks along with aggregate base parking areas will be constructed at the northeast and southwest corners of D-Unit.

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5 Survey and Geomatics

The horizontal datum for the project is the North American Datum of 1983 (NAD83). The vertical datum for the project is the NAVD88.

Topography of OWA D-Unit was prepared with a ground survey by Wood Rodgers, Inc. (WRI) in 2015. The topography is supplemented by light detection and ranging (LiDAR) mapping of the project area developed for the California Department of Water Resources (DWR) Central Valley Floodplain Evaluation and Delineation (CVFED) Program. By agreement between SBFCA and DWR, the design team obtained permission to use this data for the Feather River West Levee Project on June 16, 2010. The product contains a contour interval of 1.0 feet and ground point data (x,y, and z) every square meter. Vertical accuracy of the mapping is 0.3 feet (0.6 feet at the 95% confidence level) and horizontal accuracy is 2.0 feet (3.5 feet at the 95% confidence level).

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6 Geotechnical Design

Geotechnical design for the OWA FSR Project is presented in the Geotechnical Investigation and Recommendations Technical Memorandum (TM) included in Appendix C. The geotechnical design includes:

- Performing subsurface investigation consisting of exploratory borings, test pits, and laboratory testing, to obtain information on subsurface conditions at the locations of the proposed project features;
- Performing geotechnical analysis in support of the development of a design for the inlet weir and the paved roadway of the outlet weir;
- Developing and presenting recommendations for earthwork, including subgrade preparation, allowable fill materials, placement and compaction of fill, and suitability of on-site soil for use as fill; and
- Developing and presenting recommendations for the selected gabion design for the Inlet Weir.

6.1 Inlet Weir

The recommendation provided in the Geotechnical Investigation and Recommendations TM is to utilize the Inlet Weir design presented in the OWA FSR Hydraulic Analysis for With-Project Conditions TM by PBI (2015a). The design consists of an 18-inch-thick gabion mattress over the top and landside slope of the weir and 3-feet-by-3-feet gabion baskets at the slope transition points. The TM notes that on site cobbles are likely to be used for filling the gabion mattresses and baskets and recommends that the cobbles be between 4 and 8 inches in diameter with an average diameter (D_{50}) of 6 inches.

6.2 Outlet Weir

The Geotechnical Investigation and Recommendations TM provides a rigid pavement design for the access road adjacent to the sheetpile wall. The design is based on the California Department of Transportation Highway Design Manual (Caltrans HDM). The rigid pavement section will consist of 9-inches of jointed plain concrete pavement (JPCP) over 6-inches of aggregate base. The pavement will have dowels and tie bars as outlined in Chapter 620 of the Caltrans HDM. The aggregate base will conform to Caltrans Standard Specification Section 26-1.02A for Class 2 Aggregate Base. The aggregate base used in the pavement section will be compacted to 100 percent of the soil's maximum dry density per American Society of Testing and Materials (ASTM) D698.

6.3 Subgrade Preparation

Per the Geotechnical Investigation and Recommendations TM, the top 6 inches of subgrade in areas to receive fill (including gravel for gravel roadway areas), concrete slabs for restrooms, and gabion mattresses/baskets will be scarified, moisture conditioned, and compacted to at least 95 percent of the soil's maximum dry density.

Areas of weak or unstable soil shall be overexcavated to competent soil, or a minimum of 18 inches below finished subgrade elevation where competent soils are not encountered.

In areas that are to receive fill where the resulting subgrades are steeper than 6:1 (horizontal to vertical), keyways will be constructed at the bottoms of the slopes and benches constructed up the slopes. Keyways will extend a minimum of 3 feet below existing grades and bottoms of keyways will be level and have a minimum width of 12 feet. Benches will have a maximum step height of 3 feet.

It is noted in the TM that much of the exposed subgrade surfaces may consist of cobble-sized material, making scarification, moisture conditioning, and scarification difficult. For such conditions, compaction with at least four passes with a heavy roller compactor will be required in lieu of scarification and compaction.

6.4 Fill Material

All soil fill placed at the site will consist of engineered fill meeting the requirements presented in the Geotechnical Investigation and Recommendations TM. On site soil having no visible concentration of organic material, and free of debris and other deleterious materials, can be reused as fill. All engineered fill placed at the site, including on-site soil, shall not contain rocks or lumps larger than 6 inches in greatest dimension and contain no more than 15 percent larger than 2.5 inches.

Imported fill will be predominantly granular, meet the size requirements presented above, have no visible concentration of organic material, have a liquid limit less than 40, have a plasticity index not exceeding 15, be non-corrosive, and contain no environmental contaminants or debris.

7 Civil Design and Considerations

The OWA FSR design criteria are based on published Federal, state, and county regulations and technical guidance documents. The following section describes what criteria were used for the various components of the OWA FSR Project.

7.1 Hydraulic Model

The hydraulic model used to design the new inlet weir and other components of the project was developed by Peterson Brustad, Inc. (PBI). Development of the model is documented in OWA FSR Project Hydraulic Analysis-Baseline Model Documentation (PBI, 2015b).

7.2 Inlet Weir Design

The crest elevation, weir length, and material of the new inlet weir were developed by PBI. The design of the inlet weir is documented in OWA FSR Hydraulic Analysis for With-Project Conditions TM included in Appendix A. Design of the inlet weir was primarily governed by the objective to achieve a 0.5 foot stage reduction in the Feather River elevation during the 200-year event with a weir design that was cost efficient and constructible within the site constraints.

7.2.1 Inlet Weir Material

A number of materials were considered during the weir development stage for an overtopping weir, such as roller compacted concrete, reinforced concrete slab, reinforced rockfill, or riprap. However, the OWA has a readily available supply of river rock that could be used for rock gabions in construction of the new weir. Using this available resource reduces construction cost compared to concrete.

All materials used for overtopping protection have an allowable unit discharge measured in cfs per linear foot of protection. Analysis was performed to determine the unit discharge for the new inlet weir in the 200-year event as documented in the OWA FSR Hydraulic Information Request for Inflow Weir Design TM (PBI, 2016) included in Appendix B. The unit discharge was found to be within the allowable values for rock gabions in the TM titled OWA FSR Project Geotechnical Investigation and Recommendations by HDR (2016a). The Geotechnical Investigation and Recommendations TM is included in Appendix C.

7.2.2 Inlet Weir Length and Crest Elevation

Considering the limitation in allowable unit discharge for rock gabions, the weir length and crest elevation were designed to not exceed the allowable unit discharge while still providing a 0.5-foot stage reduction in the main channel for the 200-year flood event.

The OWA FSR Project Conceptual Alternatives Analysis Report (PBI, 2015c) discusses how a number of combinations of weir elevations and lengths were considered to find the most efficient weir design. The report concluded that a weir crest elevation of 130 feet

NAVD88 and length of 400 feet would provide both a minimum of 0.5-foot stage reduction and a unit discharge within the allowable limits for rock gabions.

The new inlet weir crest elevation of 130.0 NAVD88 will result in the weir overtopping at a flow of 71,000 cfs measured at the location of the new weir. This flow corresponds to approximately a 10-year flood event.

7.3 Outlet Weir Improvements

The sheetpile wall outlet weir is located along the western dike of the OWA D-Unit. Under existing conditions, water flows both into and out of the D-Unit over the weir. The outlet weir was analyzed in the OWA FSR Alternatives Analysis Report for the following:

- Existing performance deficiencies
- Hydraulic effects on the outlet weir due to the new inlet weir
- Potential improvements

It was found that the outlet weir did not necessarily need to be improved in order to meet project goals. However, it was recommended that the service life of the existing outlet weir be extended by placing rock slope protection on the north and south sides of the sheetpile wall and the north side of the adjacent access road, as well as providing a hardened concrete surface on the access road. Design of the rock slope protection is documented in the TM Riprap Design for Sites 2, 5, and 9 by HDR (2016b) included in Appendix D.

7.4 Low Flow Outlet Design

The low flow outlet is currently a 60-inch diameter culvert located at the southwest corner of the D-Unit. Upstream of this culvert is an existing 100 foot to 200 foot wide channel which acts as an overflow for Lower Pacific Heights Pond. The outlet from the pond to the channel is a 60 inch diameter culvert with a berm and access road over it. The low flow outlet was analyzed in the OWA FSR Alternatives Analysis Report for the following:

- Existing performance deficiencies
- Hydraulic effects on the low flow outlet due to the new inlet weir
- Potential improvements

It was found that this low flow outlet system acts as a bottleneck and restricts water from flowing out of D-Unit during high flow events. Additionally, it was found that 200-year flood flows were likely to wash out the culvert and berm at the Lower Pacific Heights Pond outlet.

In order to remove the bottleneck at this location, the berm and culvert at the pond will be removed and replaced with a hardened concrete-paved road flush with the channel. The 60-inch culvert between the channel and Feather River will be replaced with three temporary 72-inch culverts.

7.5 Recreation Features

Recreation features were designed with the objective of balancing hunting, fishing, and land use with maintenance of species populations and ecological value. CDFW manages the OWA D-Unit for public recreational use that is consistent with Fish and Game regulations and provides and encourages activities that do not impede the intrinsic and ecological values of the site.

Design criteria applicable to recreation features are based on input from CDFW and SBFCA and standard engineering practice. The following section describes the criteria followed for recreation feature design.

7.5.1 Roadways and Parking Lots

The following criteria were followed for all roadways, river access ramps, and parking lots:

- Vehicular roadways were designed to have a 10% or flatter longitudinal slope with the exception of the river access ramp at the southwest corner of the D-Unit. Due to existing topography, the access ramp at this location will have a maximum longitudinal slope of 12%.
- Site grading was designed to a 1% cross slope to encourage proper drainage and eliminate ponding.
- 6-inches of aggregate base will be placed on all parking areas and access roads to support vehicle and recreational vehicle loads.
- 2- to 3-foot diameter boulders will be placed to control vehicle and foot traffic in select areas.

7.5.2 Culvert Design

The culvert under the new earthen access ramp will be 24-inches in diameter. Culvert sizing calculations are documented in Culvert Sizing for Proposed Road Crossing in the Oroville Wildlife Area D-Unit by PBI (2015d).

7.5.3 Portable Restroom Slab

The portable restroom slab was designed to accommodate two regular portable restrooms and one Americans with Disabilities Act (ADA)-compliant portable restroom. The slab will be 30-feet by 22-feet and 1-foot-thick. Design references used for the slab design are as follows:

- ACI 318
- ASCE 7-10
- IBC 2009
- Butte County Development Services- Building Division Design Criteria Form No. DCP 5
- AASHTO Bridge Design Manual

Design of the slab is documented in the TM Portable Toilet Foundation Slab Design by HDR (2016c) included in Appendix E of this BODR.

7.6 Site Access

Access to the OWA D-Unit is from Pacific Heights Road at the northeast corner of the unit which allows traffic onto the northern dike. This access point will be utilized for mobilizing equipment for construction as well as for hauling material into and out of the D-Unit.

The access road will be affected by construction of the new inlet weir. A new access road will be constructed which extends from the existing road on the top of the dike to the landside toe of the new weir then continues back up to the existing access road on the other side of the weir.

7.7 Tree and Vegetation Removal

Removal of vegetation and tree stumps incidental to the work will be completed during project construction. Tree removal is limited to only those trees that fall within grading limits. Otherwise, trees and vegetation will be protected in place.

7.8 Borrow Sources

Material for the gabion rock weir is available from within the D-Unit. Sources for rock slope protection, aggregate base, and boulders for the project will be identified by the Contractor and will likely come from commercial sources located near the Yuba City, Marysville, and Oroville areas.

7.9 Quantity Calculations

Quantities were determined based on the designs leading up to the 65% submittal. Earthwork quantities were determined by a combination of hand calculations and spreadsheets. A summary of quantities is included in Appendix F.

7.10 Construction Schedule

It is currently anticipated that the OWA FSR Project will begin construction in early 2017 and be completed in 2018. The typical construction season is from April 15 to October 31.

Figures

February 1, 2016

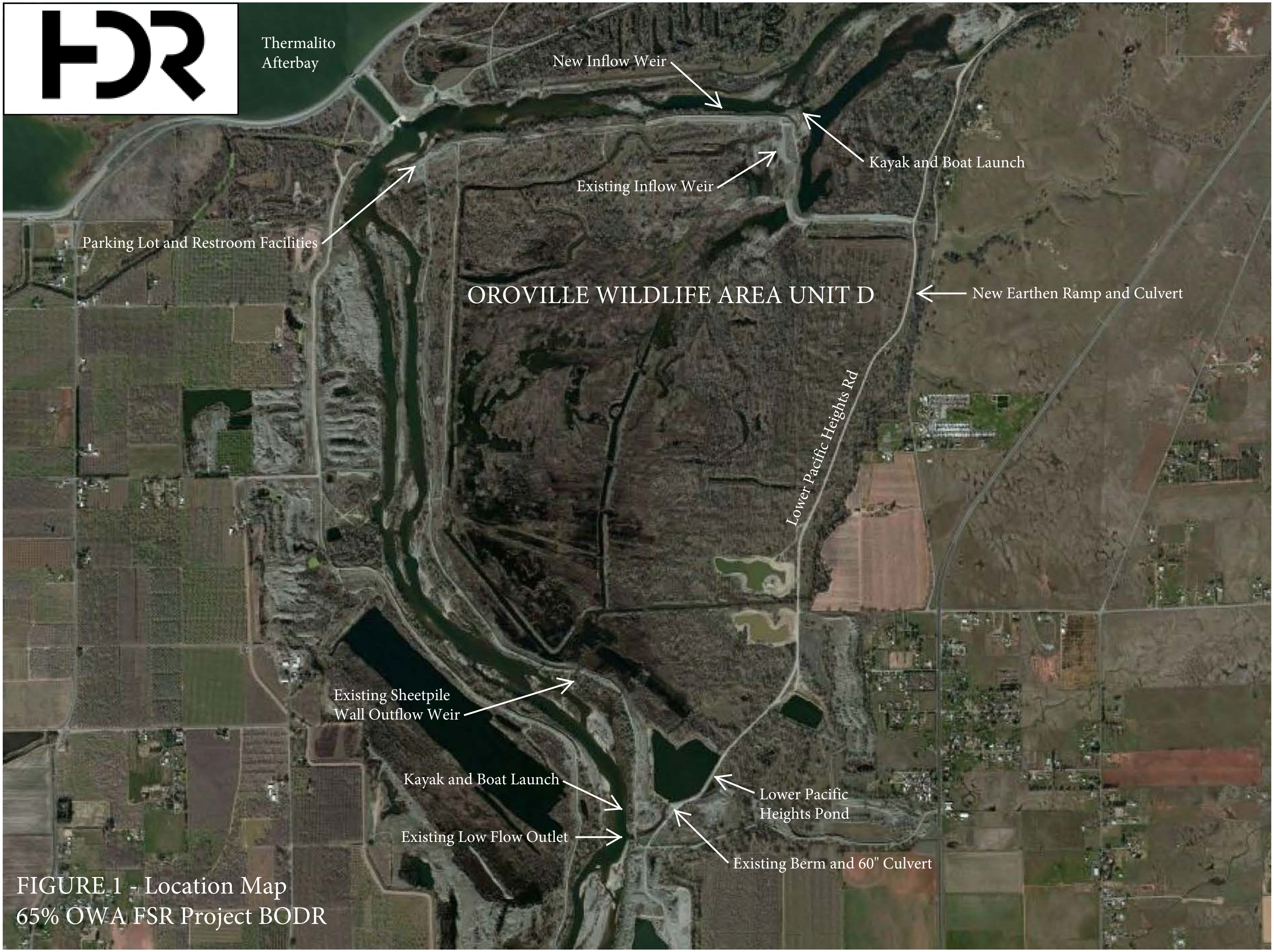

FIGURE 1 - Location Map
65% OWA FSR Project BODR

Appendix A. Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Analysis for With-Project Conditions Technical Memorandum, December 15, 2015

Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Analysis for With-Project Conditions

Prepared for: Sutter Butte Flood Control Agency **December 15, 2015**

Prepared by: Vadim Demchuk, EIT
Reviewed by: Chris Fritz, PE, CFM

INTRODUCTION

This Technical Memorandum (TM) documents the hydraulic analysis performed by Peterson Brustad, Inc. (PBI) for the Sutter Butte Flood Control Agency (SBFCA) Oroville Wildlife Area (OWA) Flood Stage Reduction (FSR) project. The TM describes the hydraulic impacts associated with the preferred alternative (with-project) conditions. For the analysis, hydraulic model simulations were conducted for with-project conditions using PBI's existing TUFLOW model for the 2-year, 100-year, 200-year, and 1957 design flow events. Development of the TUFLOW model, calibration of the baseline (without-project) condition, and documentation of the n-year hydrology is described in PBI's Model Development Report[1]. Table 1 below summarizes the various scenarios analyzed as part of this TM.

Table 1. Summary of With-Project Scenarios

SCENARIO	TUFLOW Model Simulation File Name[2]	Peak Feather River Inflow (cfs)
2-year With-Project	OWA_50ft_alt_006	15,000
100-year With-Project	OWA_50ft_100yr_048	150,000
200-year With-Project	OWA_50ft_200yr_025b	174,000
1957 Design Flow With-Project Conditions	OWA_OWA_50ft_Post_Project_18	210,000

SUMMARY OF WITH-PROJECT CONDITIONS

A summary of the preferred alternative for the OWA FSR Project is shown in Figure 1. The development of the preferred alternative is described in PBI's Conceptual Alternatives Analysis Report[3].

The preferred project consists of the following four main hydraulic features:

[1] *Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Analysis-Baseline Model Documentation*, Peterson Brustad., August 2015.
[2] TUFLOW file names generally reference grid size, n-year event/geometry description, and run number
[3] *Oroville Wildlife Area Flood Stage Reduction Project: Conceptual Alternatives Analysis Report,* Peterson Brustad, August 2015.

Figure 1. Summary of the OWA FSR Project Main Features

Construction of New 400' Rock Gabion Inflow Weir: The proposed project would construct a new 400-foot-long rock gabion weir at the northeast end of the OWA D-Unit. The weir is essentially a notch in the existing berm that will allow high flows from Feather River to enter the OWA.

Construction of New Notch Connection to the Feather River: The project would construct a notch connection through the existing berm along the eastern boundary of the project area to re-connect the Feather River to the interior of the OWA. The new permanent connection would be a box culvert, or series of box culverts, with sluice gate(s) intended to provide more frequent inundation of the project area during times of low flow (i.e. during the 2-year event). The sluice gate(s) will be closed during high water events (i.e. during the 100-year/200-year events).

Construction of New Fish Barrier Berm: The proposed project would construct approximately 3,000 linear feet of berm improvements along the north side of Pit Number 2 pond. The sole purpose of the new berm is to prevent fish access into the Pit No. 2 pond (located in the southern part of the project area), which has been identified as a fish stranding hazard.

Construction of Interior Canal Grading Improvements: The proposed project includes minor grading improvements to approximately 7,500 linear feet of existing channels in the interior of the OWA. The purpose of the improvements is to enhance fish passage into and out of the area and to improve fish rearing/wetland habitat.

2-YR WITH-PROJECT RESULTS

Hydraulic modeling results for the 2-year with-project scenario show backwater from the Feather River flowing into the project area via the proposed new permanent connection and creating approximately 150 acres of new 2-yr shallow floodplain habitat. The proposed new fish barrier berm (located in the southern part of the project area) effectively prevents water from entering the Pit 2 southern pond from the north. The simulation also shows water from the Feather River backing up into the Pit 2 pond via the low flow outlet spillway channel.

The table in Attachment A summarizes the peak flows, shear stresses, velocities, and water surface elevations (WSEL) at the new permanent connection for the 2-yr with-project condition. Modeling results for the 2-year with-project scenario are included in Attachment B. Attachment B contains figures showing:

- 2-yr With-Project Max Depths
- 2-yr With-Project Max Shear Stresses
- 2-yr With-Project Max Velocities
- 2-yr With-Project Max WSEL
- 2-yr With-Project Velocity Changes
- 2-yr With-Project WSEL Changes

100-YEAR & 200-YEAR WITH-PROJECT RESULTS

Hydraulic modeling results for the 100-year and 200-year scenarios show that once flows in the Feather River main channel reach about 40,000 cubic feet per second (cfs), water begins to flow into the project area through the existing outflow weir. Once flows in the main channel reach about 60,000 cfs, water then begins to spill into the project area through the existing rock gabion inflow weir.

Hydraulic modeling results for the 100-year and 200-year scenarios show water spilling into the project area via the proposed new inflow weir once flows in the main channel reach approximately 70,000 cfs. A peak flow of ~7,000 cfs and 15,000 cfs is diverted through the new inflow weir, which results in a maximum stage reduction of 0.3’ and 0.7’ in the main channel of the Feather River for the 100-year and 200-year events respectfully.

The modeling results show very little change in regards to the extents of inundation in the project area for both the 100-year and 200-year events since, under existing conditions, water already fully inundates the project area due to the existing inflow and outflow weirs.

The model simulations show about a 0.5’ increase in stage in the main channel of the Feather River near the location of the existing outflow weir. However, this section of the main channel is separated from the Feather River West Levee (FRWL) by a large existing berm (and One Mile pond) and results show that water surface elevations adjacent to the FRWL do not increase as a result of the 100-yr and 200-yr with-project condition. In addition, there are no significant downstream WSEL impacts shown beyond River Mile 56, which is within the relative extents of the project.

The table in Attachment A summarizes the peak flows, shear stresses, velocities, and WSEL’s over the inflow weir and outflow weir for the 100-yr and 200-year with-project conditions. Modeling results for the 100-year and 200-year with-project scenarios are included in Attachments C and D respectively. Attachments C and D contain figures showing:

- 100-yr & 200-yr With-Project Max Depths
- 100-yr & 200-yr With-Project Max Shear Stresses
- 100-yr & 200-yr With-Project Max Velocities
- 100-yr & 200-yr With-Project Max WSEL
- 100-yr & 200-yr With-Project Velocity Changes
- 100-yr & 200-yr With-Project WSEL Changes

1957 DESIGN WITH-PROJECT RESULTS

Similar to the 100-year and 200-year scenarios, hydraulic modeling results for the with-project 1957 design flow scenario show little changes in regards to the extents of inundation. A peak flow of ~39,000 cfs is conveyed into the OWA via the new inflow weir which results in a maximum stage reduction of 0.5’ in the main channel of the Feather River. It should be noted, however, that overtopping of the perimeter berms (surrounding the project area) occurs in many different places during the simulated 1957 design flow event.

Also similar to the 100-year and 200-year scenarios, the model simulations show a 0.5' increase in stage in the main channel of the Feather River near the location of the existing outflow weir. However, this section of the main channel is separated from the Feather River West Levee (FRWL) by a large existing berm and pond and the results show that water surface elevations adjacent to the FRWL do not increase as a result of the 1957 design flow with-project condition. In addition, there are no downstream WSEL impacts shown beyond River Mile 56.

The table in Attachment A summarizes the peak flows, shear stresses, velocities, and WSEL's over the inflow weir and outflow weir for the 1957 design flow with-project condition. Modeling results for the 1957 with-project scenarios are included in Attachments E. Attachment E contains figures showing:

- 1957 Design Flow With-Project Velocity Changes
- 1957 Design Flow With-Project WSEL Changes

ATTACHMENT A
HYDRAULIC SUMMARY TABLE
FOR WITH-PROJECT CONDITIONS

Attachment A. Hydraulic Summary Table

Scenario	Max Stage Reduction in the Feather River Main Channel (ft)	Existing Inflow Weir	400 ft Inflow Weir @ 130 ft-NAVD88					Outflow Weir					New Permanent Connection				
		Peak Flow - IN (cfs)	Peak Flow - IN (cfs)	Peak Flow - OUT (cfs)	Max Shear Stress (lb/ft^2)	Max Velocity (fps)	Max WSE (ft-NAVD88)	Peak Flow - IN (cfs)	Peak Flow - OUT (cfs)	Max Shear Stress (lb/ft^2)	Max Velocity (fps)	Max WSE (ft-NAVD88)	Peak Flow - IN (cfs)	Peak Flow - OUT (cfs)	Max Shear Stress (lb/ft^2)	Max Velocity (fps)	Max WSE (ft-NAVD88)
2-yr With-Project	-	-	-	-	-	-	-	-	-	-	-	-	632	-	0.03	0.7	102.9
100-yr With-Project	0.3	25,000	7,000	-	22.1	22.8	132.4	8,000	23,000	22.8	14.5	120.3	-	-	-	-	-
200-yr With-Project	0.7	33,000	15,000	-	31.8	27.9	133.3	10,000	29,000	20.8	13.7	122	-	-	-	-	-
57 Design Flow With-Project	0.5	53,000	39,000	-	40.0	32.7	136.2	25,000	33,000	20.1	15.7	123.2	-	-	-	-	-

ATTACHMENT B
2-YR WITH-PROJECT RESULTS

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N

0 1,200 Feet

1 in. = 1,200 ft.

January 14, 2016

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
2-YR HISTORICAL WITH-PROJECT
MAX DEPTH

PETERSON . BRUSTAD . INC
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

N

0 700 Feet

January 14, 2016

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
2-YR HISTORICAL WITH-PROJECT
MAX SHEAR STRESS

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ENGINEERING . CONSULTING

1180 Iron Point Rd., Suite 260
Folsom, CA 95630

Phone: (916) 608-2212
Fax: (916) 608-2232

N

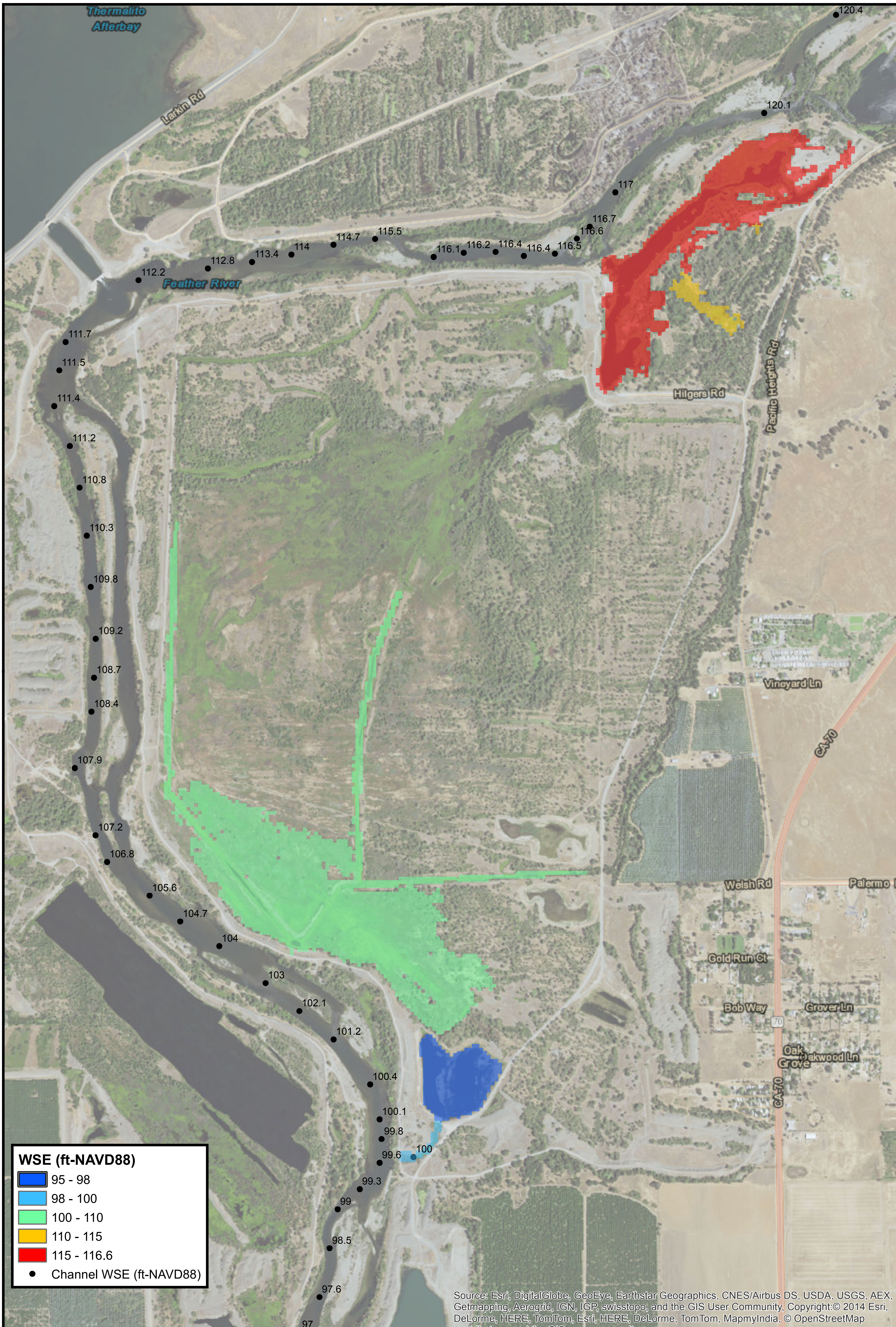
0 1,200 Feet

1 in. = 1,200 ft.

January 14, 2016

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
2-YR HISTORICAL WITH-PROJECT
MAX VELOCITY



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ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

N

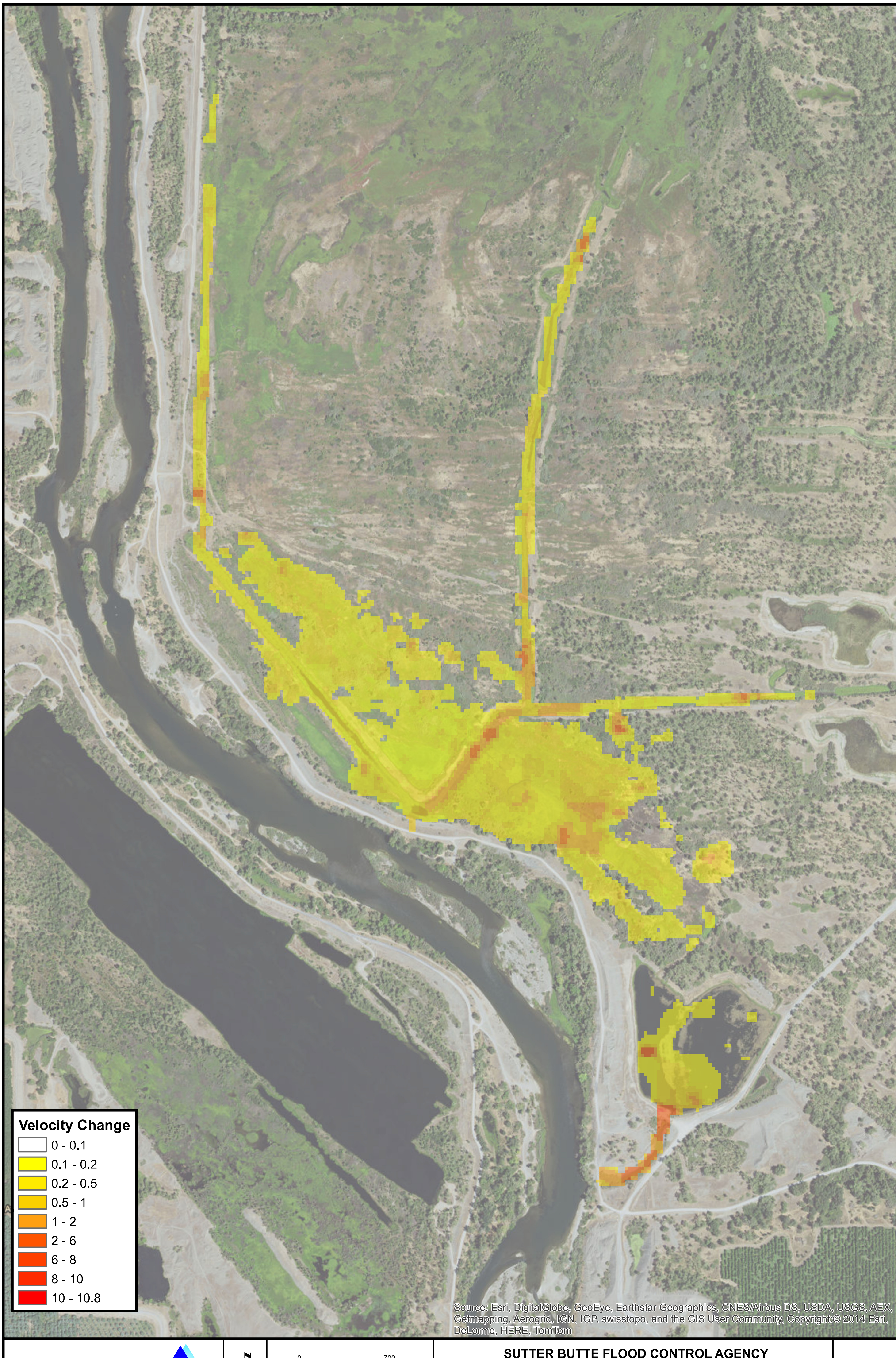
0 1,200 Feet

1 in. = 1,200 ft.

January 14, 2016

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
2-YR HISTORICAL WITH-PROJECT
MAX WSE



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ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

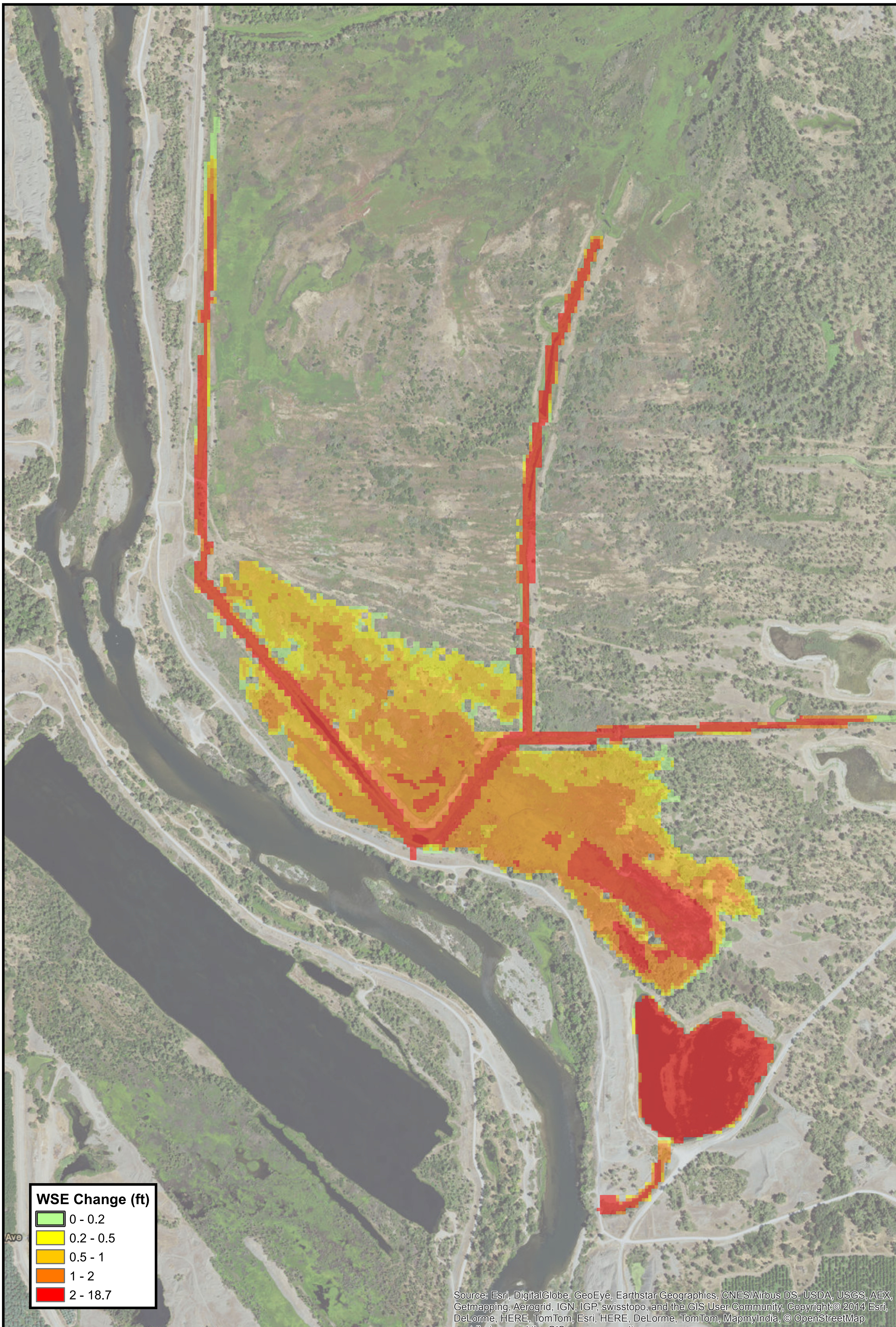
N

0 700 Feet

January 14, 2016

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
2-YR HISTORICAL WITH-PROJECT VS. 2-YR HISTORICAL BASELINE
VELOCITY CHANGE



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ENGINEERING . CONSULTING

1180 Iron Point Rd., Suite 260
Folsom, CA 95630

Phone: (916) 608-2212
Fax: (916) 608-2232

N

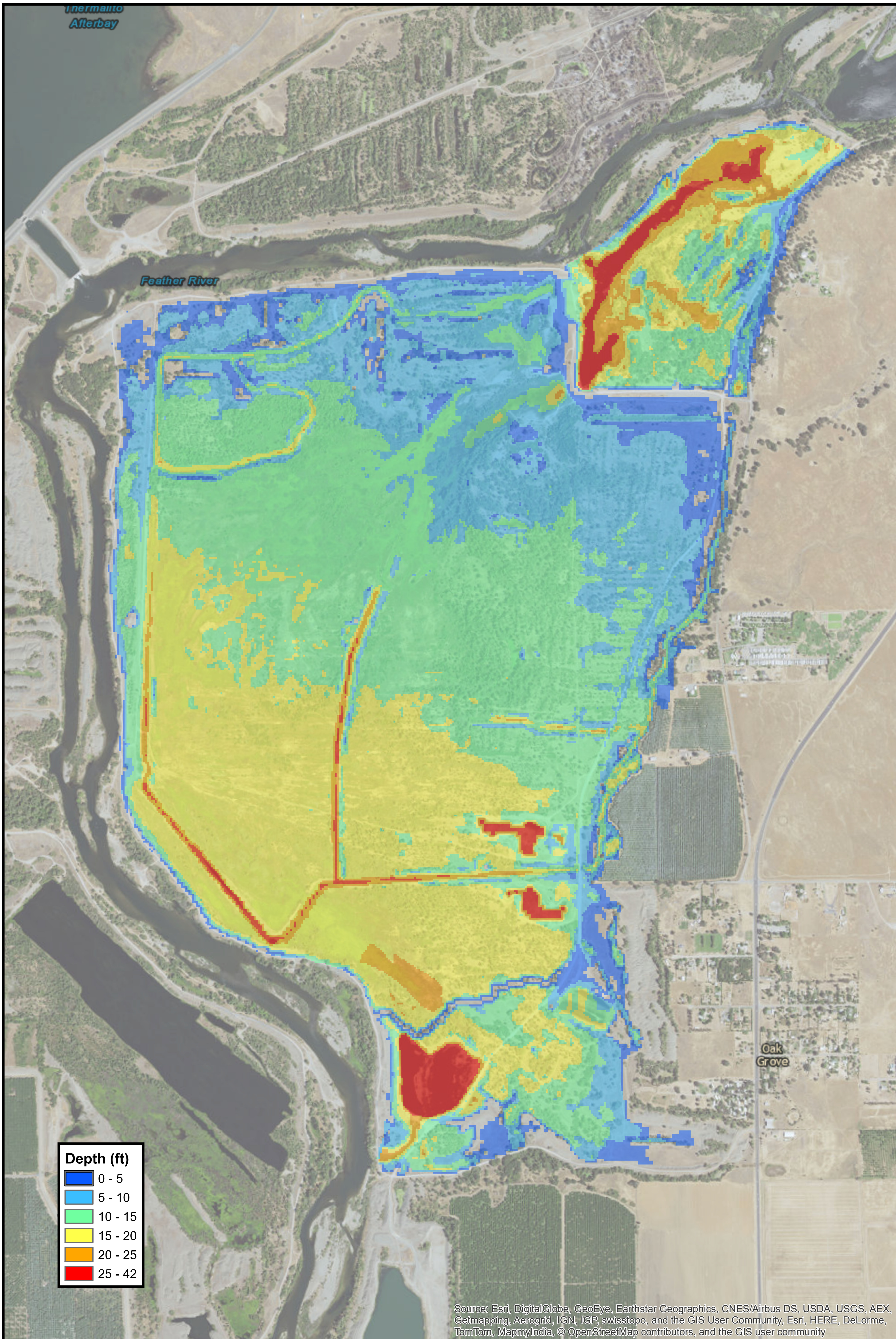
0 700 Feet

January 14, 2016

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
2-YR HISTORICAL WITH-PROJECT VS. 2-YR HISTORICAL BASELINE
WSE CHANGE

ATTACHMENT C
100-YR WITH-PROJECT RESULTS



PETERSON . BRUSTAD . INC
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

N

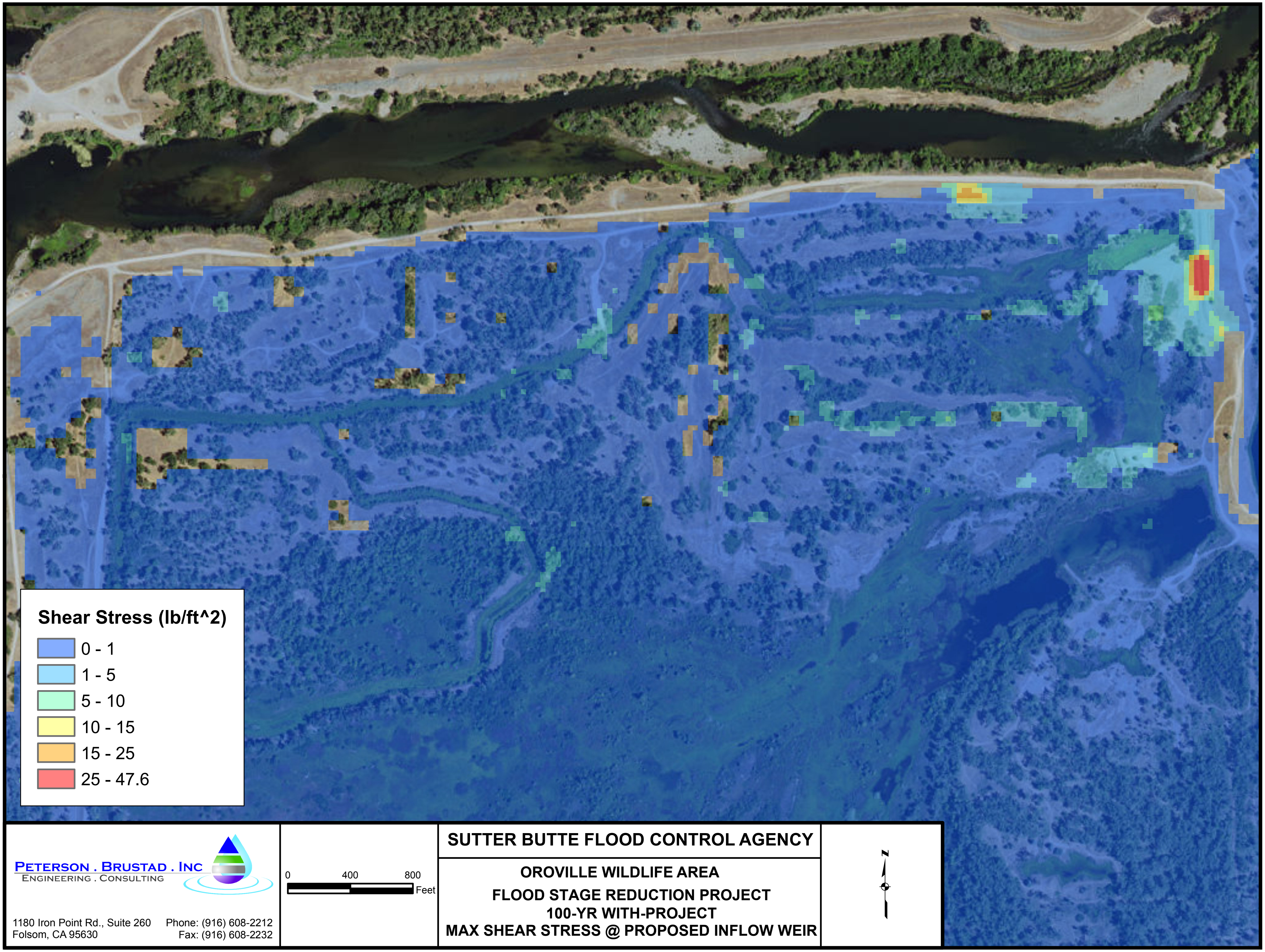
0 — 1,200 Feet

1 in. = 1,200 ft.

September 16, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
100-YR WITH-PROJECT
MAX DEPTH



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ENGINEERING . CONSULTING

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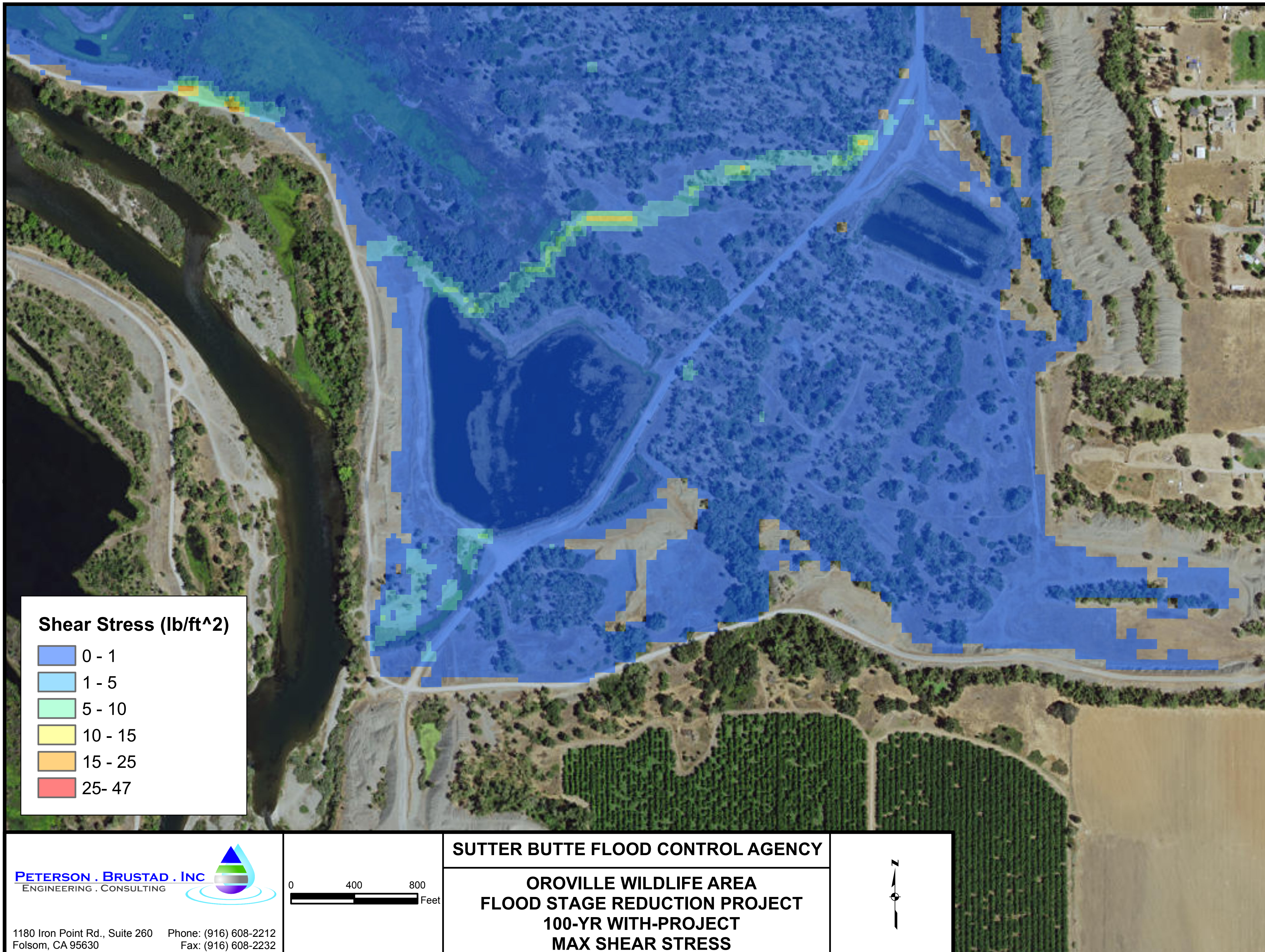
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
100-YR WITH-PROJECT
MAX SHEAR STRESS @ PROPOSED INFLOW WEIR



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ENGINEERING . CONSULTING

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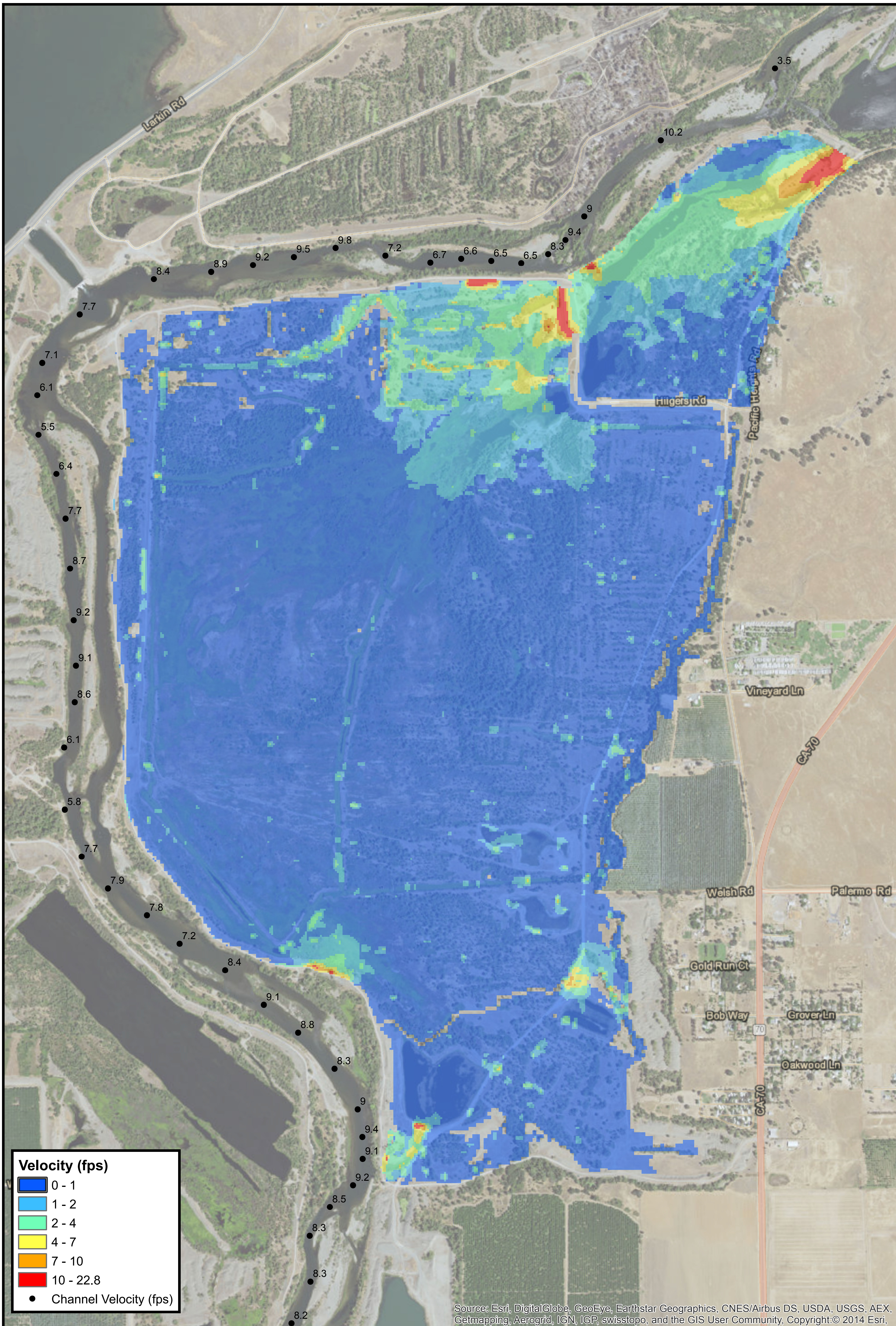
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
100-YR WITH-PROJECT
MAX SHEAR STRESS



PETERSON . BRUSTAD . INC
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

N

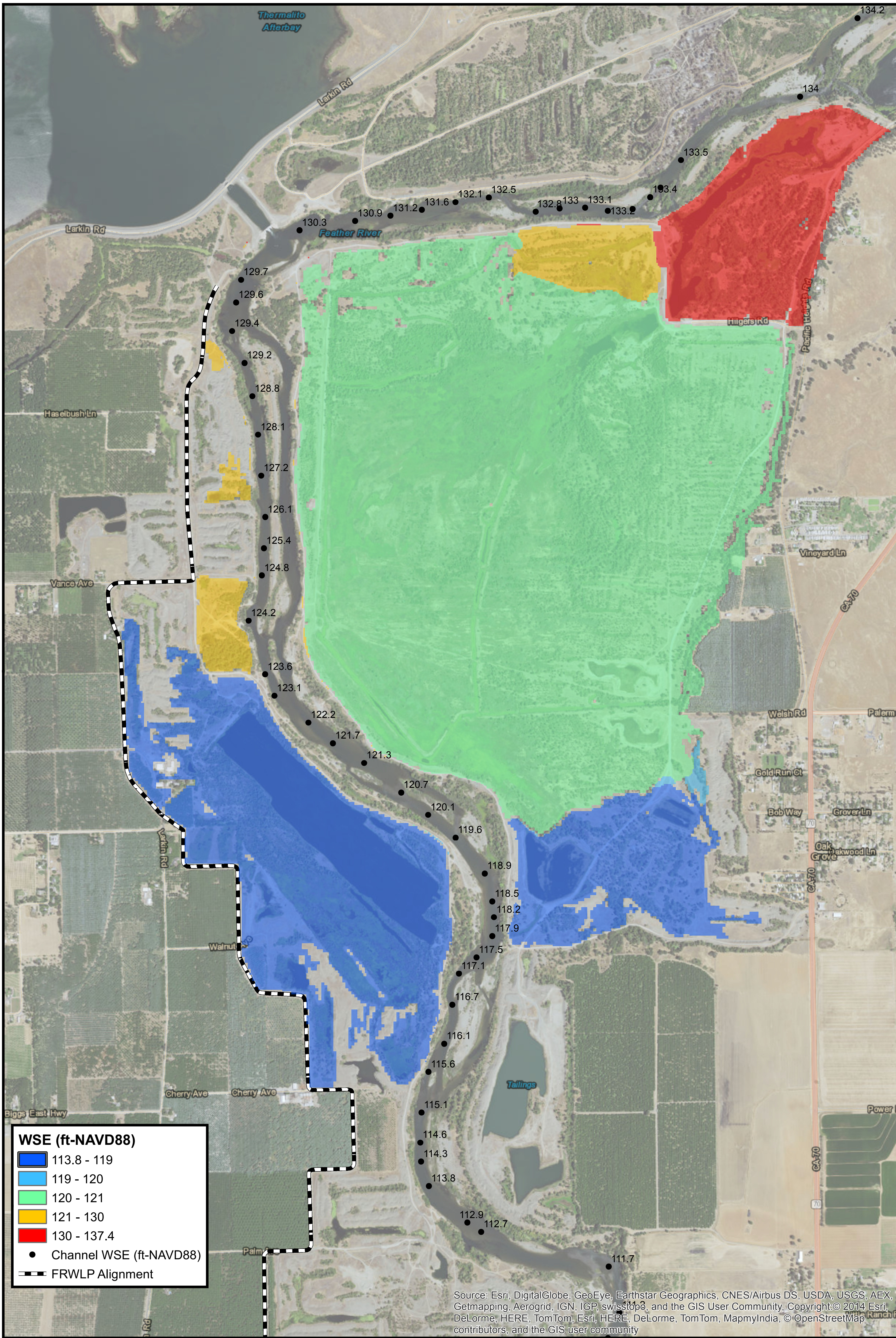
0 1,200 Feet

1 in. = 1,200 ft.

September 29, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
100-YR WITH-PROJECT
MAX VELOCITY



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ENGINEERING . CONSULTING

1180 Iron Point Rd., Suite 260
Folsom, CA 95630

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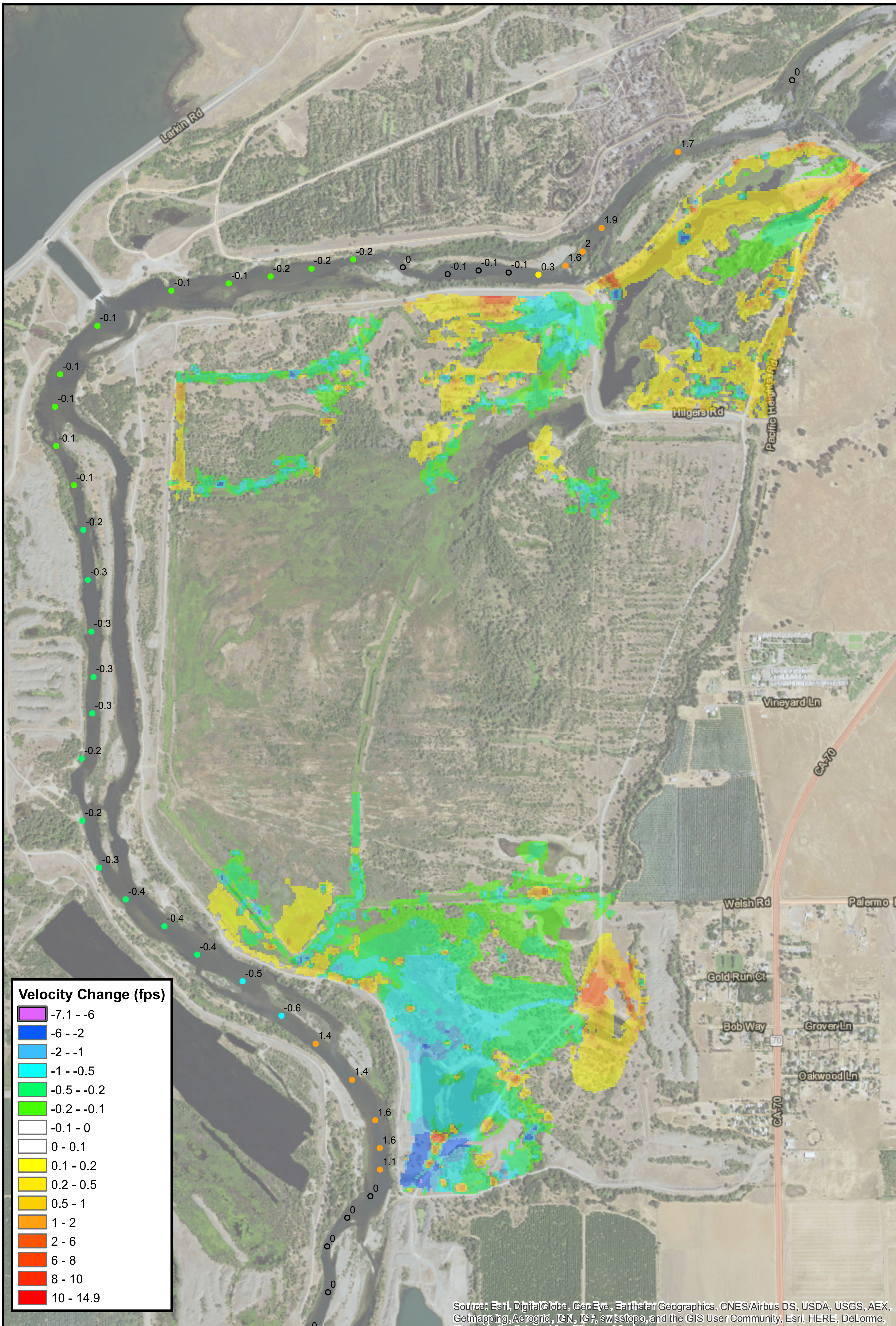
Fax: (916) 608-2232

N

January 11, 2016

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
100-YR WITH-PROJECT
MAX WSE



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ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

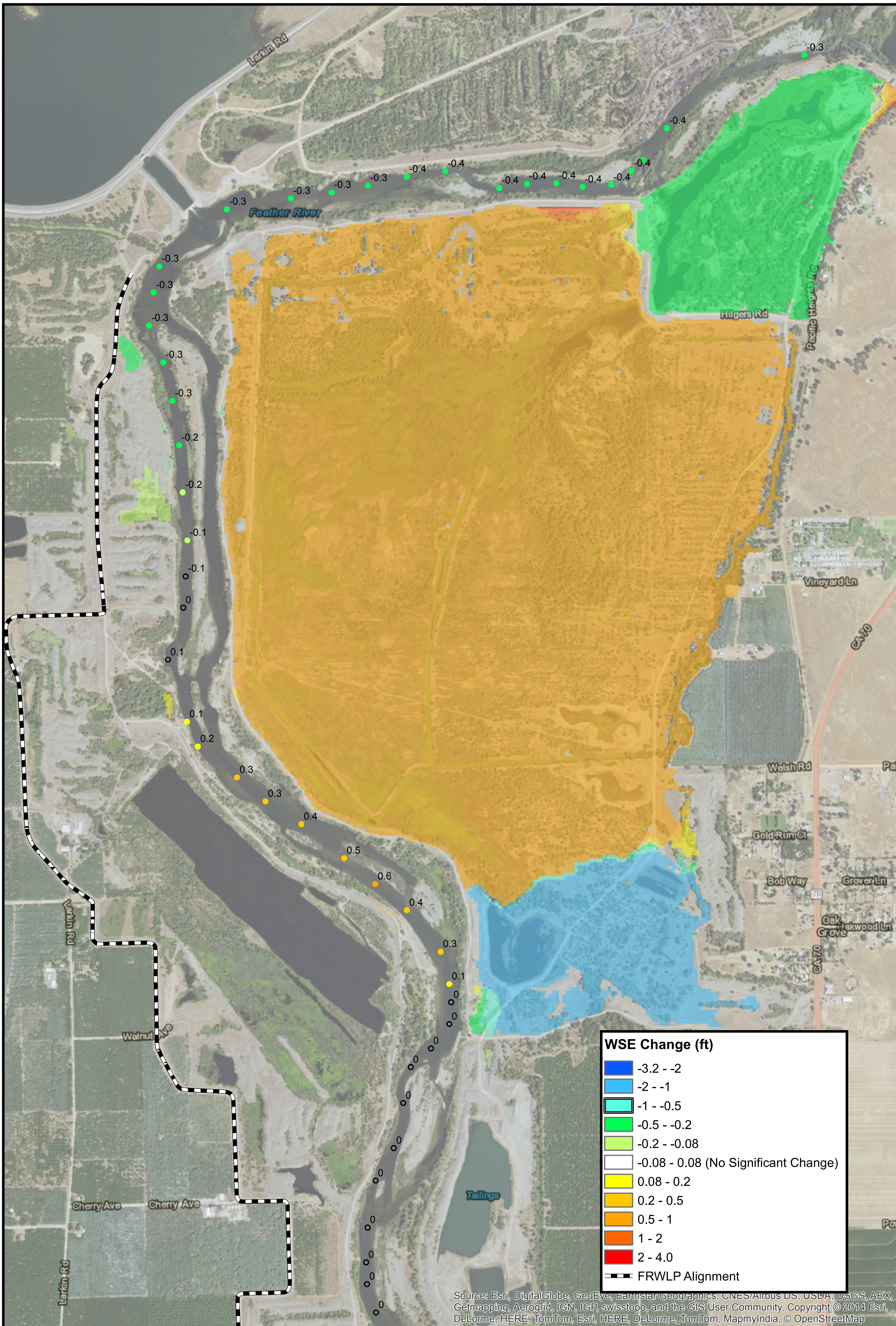
N

0 1,200 Feet

September 29, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
100-YR WITH-PROJECT VS. 100-YR BASELINE
VELOCITY CHANGE



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ENGINEERING . CONSULTING

1180 Iron Point Rd., Suite 260
Folsom, CA 95630

Phone: (916) 608-2212
Fax: (916) 608-2232

N

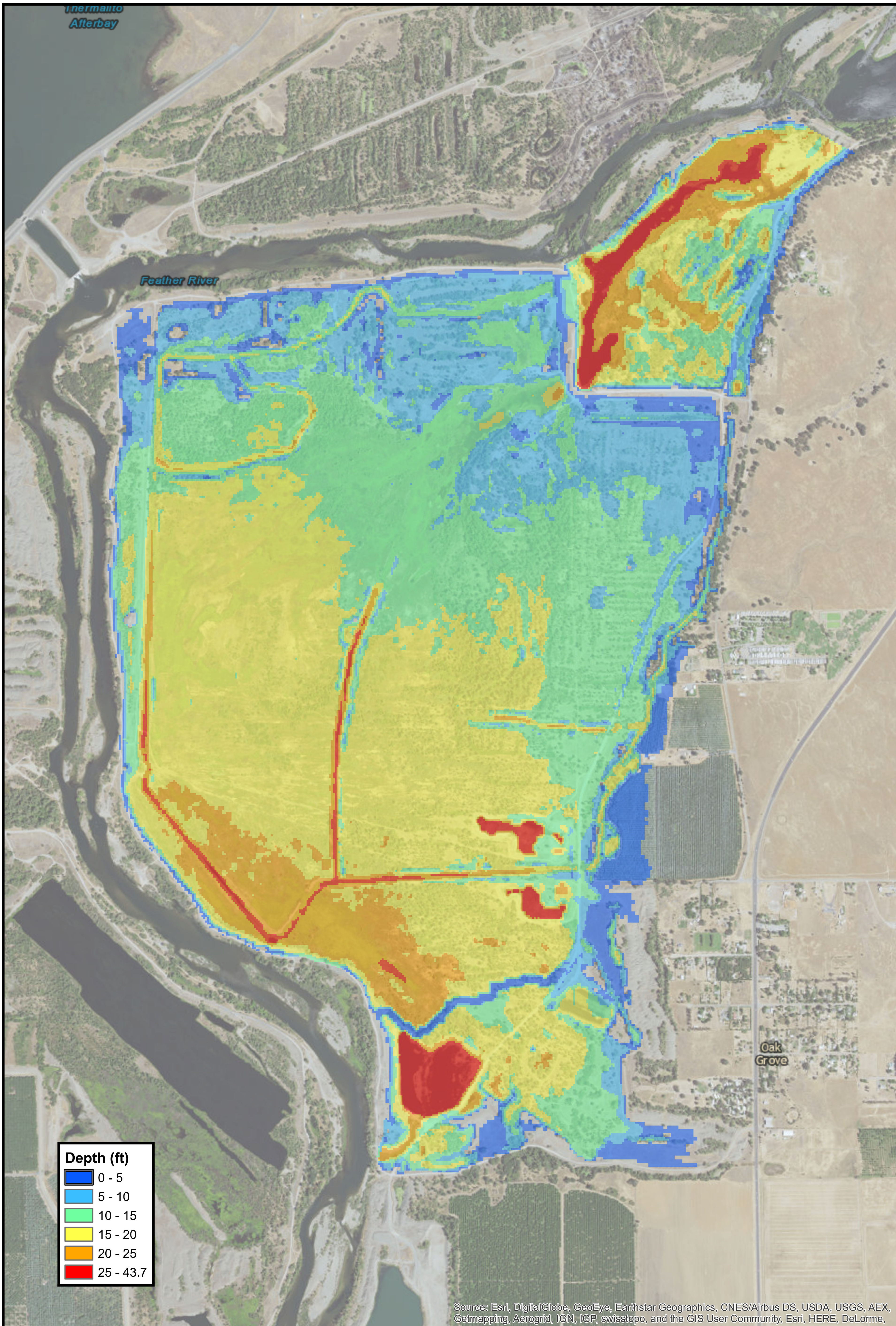
0 1,200
Feet

January 11, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJET
100-YR WITH-PROJECT VS. 100-YR BASELINE
WSE CHANGE

ATTACHMENT D
200-YR WITH-PROJECT RESULTS



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ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

N

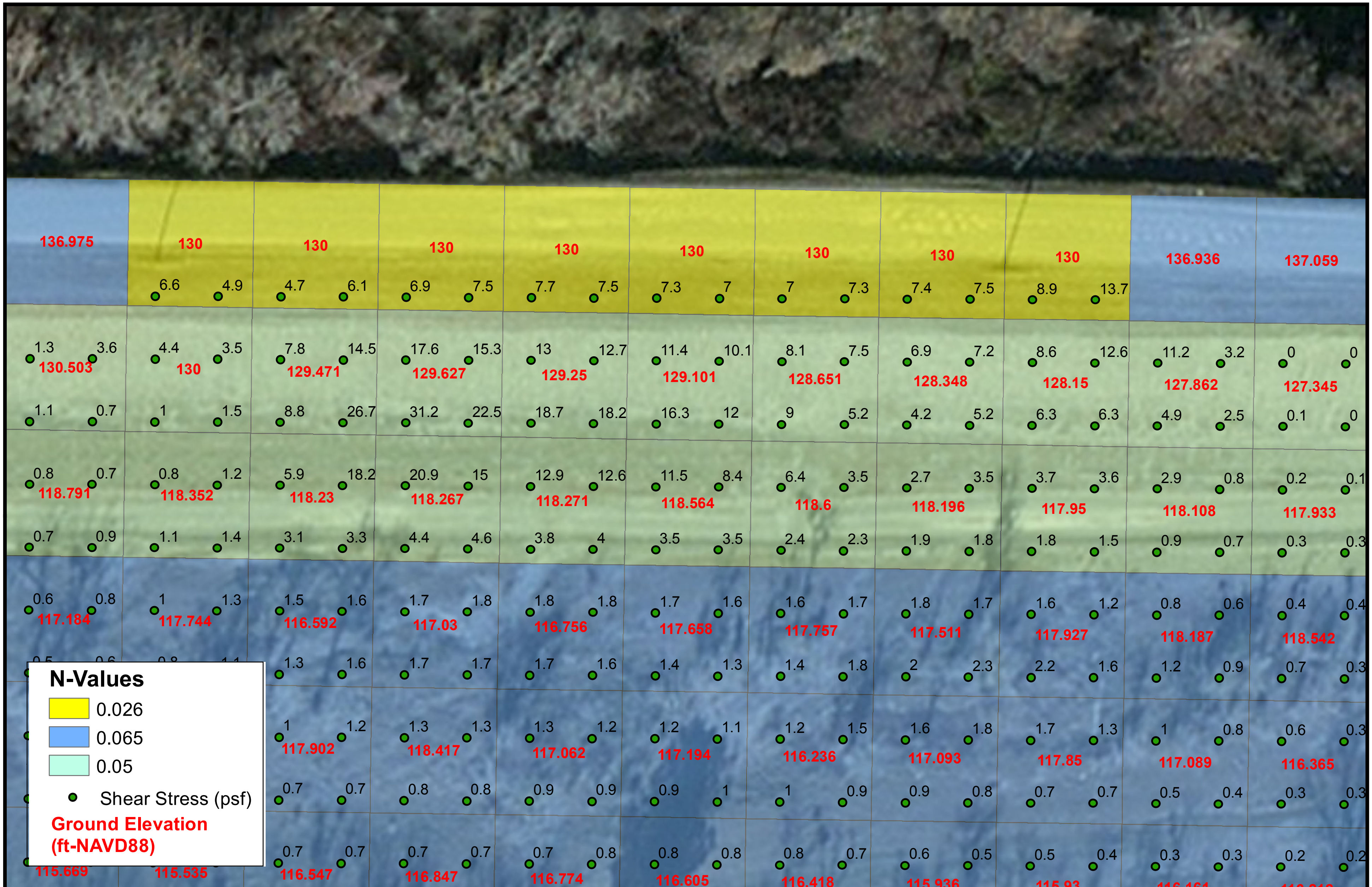
0 1,200 Feet

1 in. = 1,200 ft.

September 16, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT
MAX DEPTH



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ENGINEERING . CONSULTING
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Folsom, CA 95630
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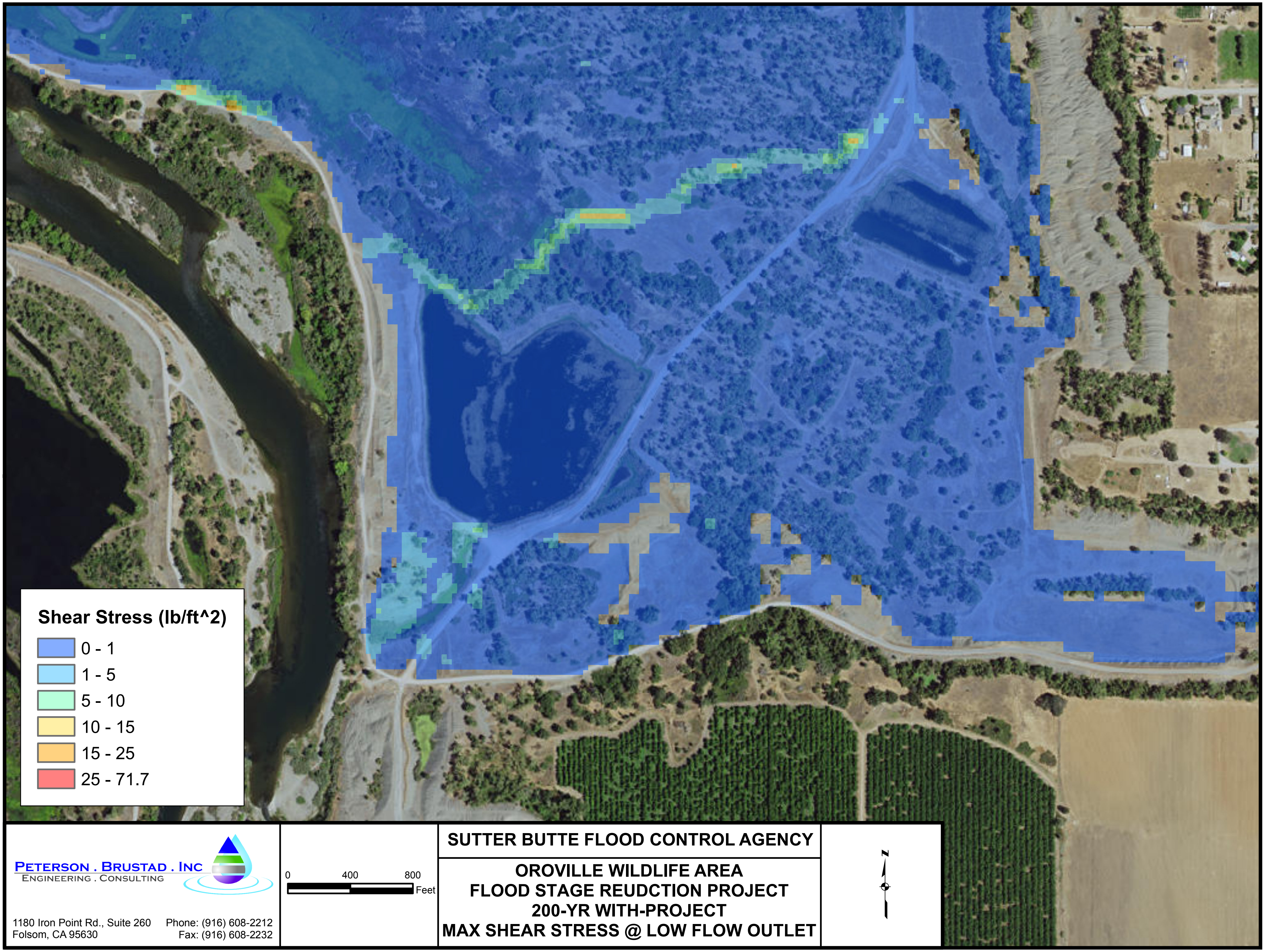
SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH PROJECT
MAX SHEAR STRESS @ PROPOSED INFLOW WEIR



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ENGINEERING . CONSULTING

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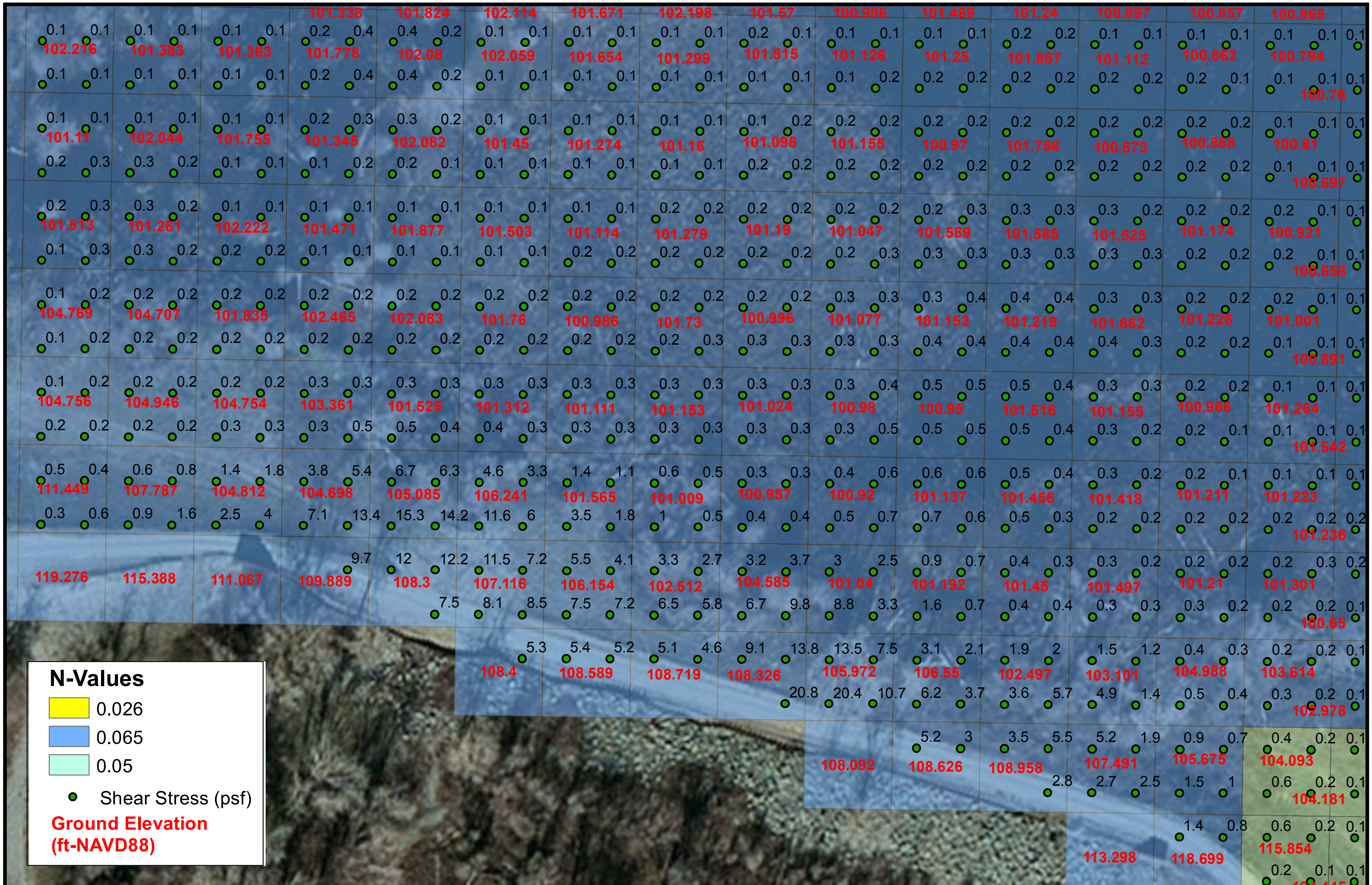
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REUDCTION PROJECT
200-YR WITH-PROJECT
MAX SHEAR STRESS @ LOW FLOW OUTLET



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ENGINEERING . CONSULTING

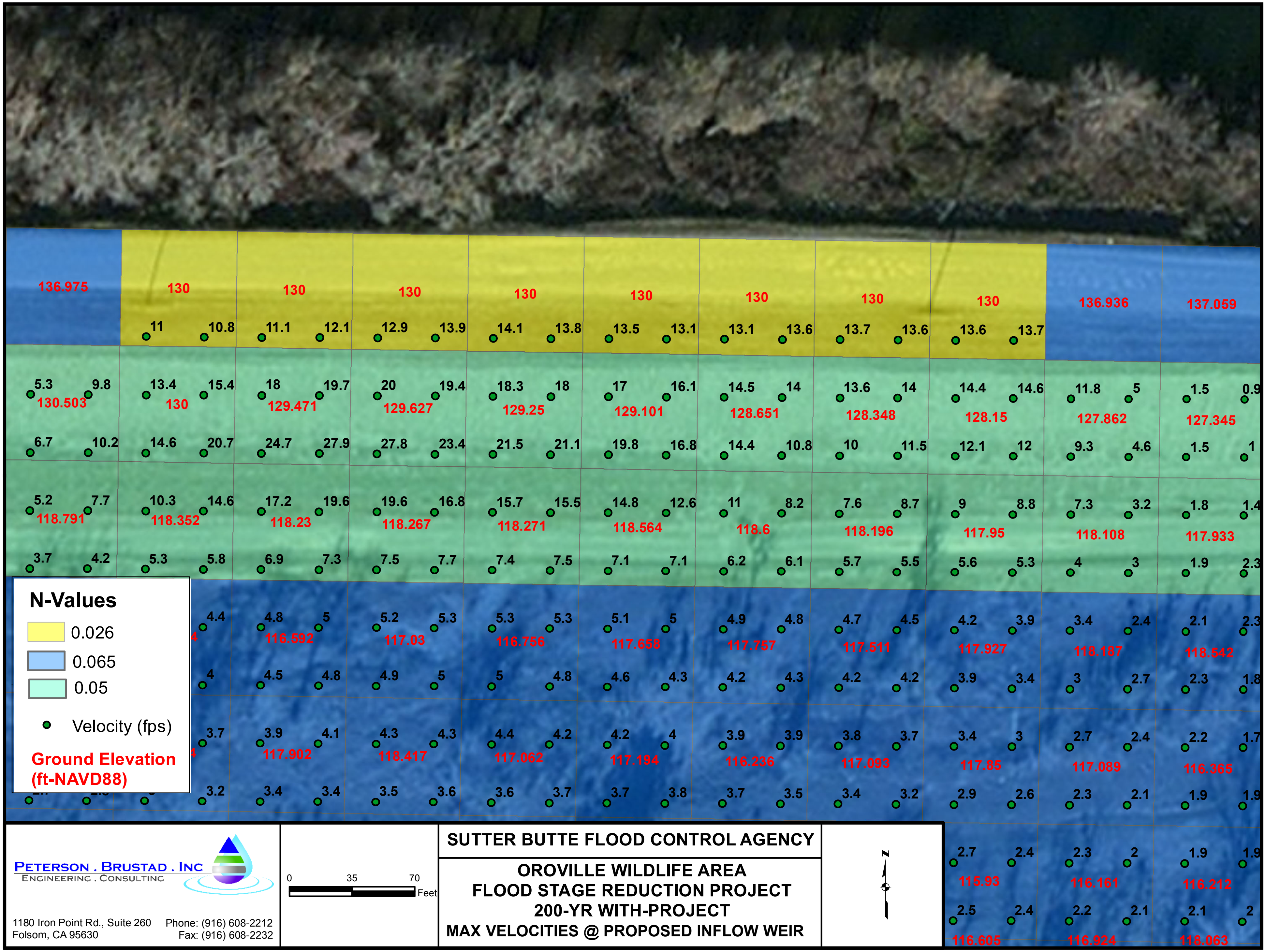
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

0 50 100 Feet

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT
MAX SHEAR STRESS @ OUTFLOW WEIR

N



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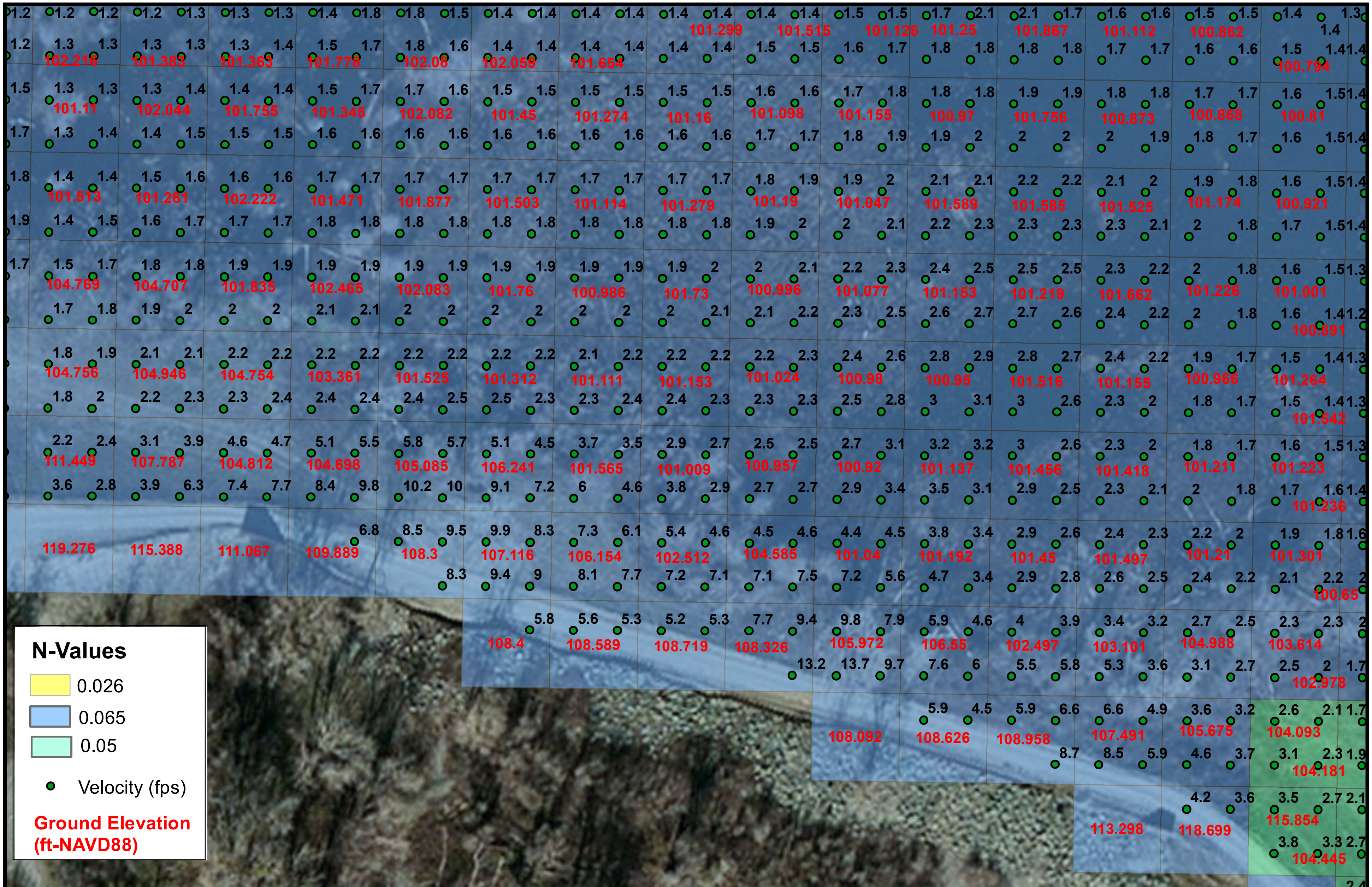
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT
MAX VELOCITIES @ PROPOSED INFLOW WEIR



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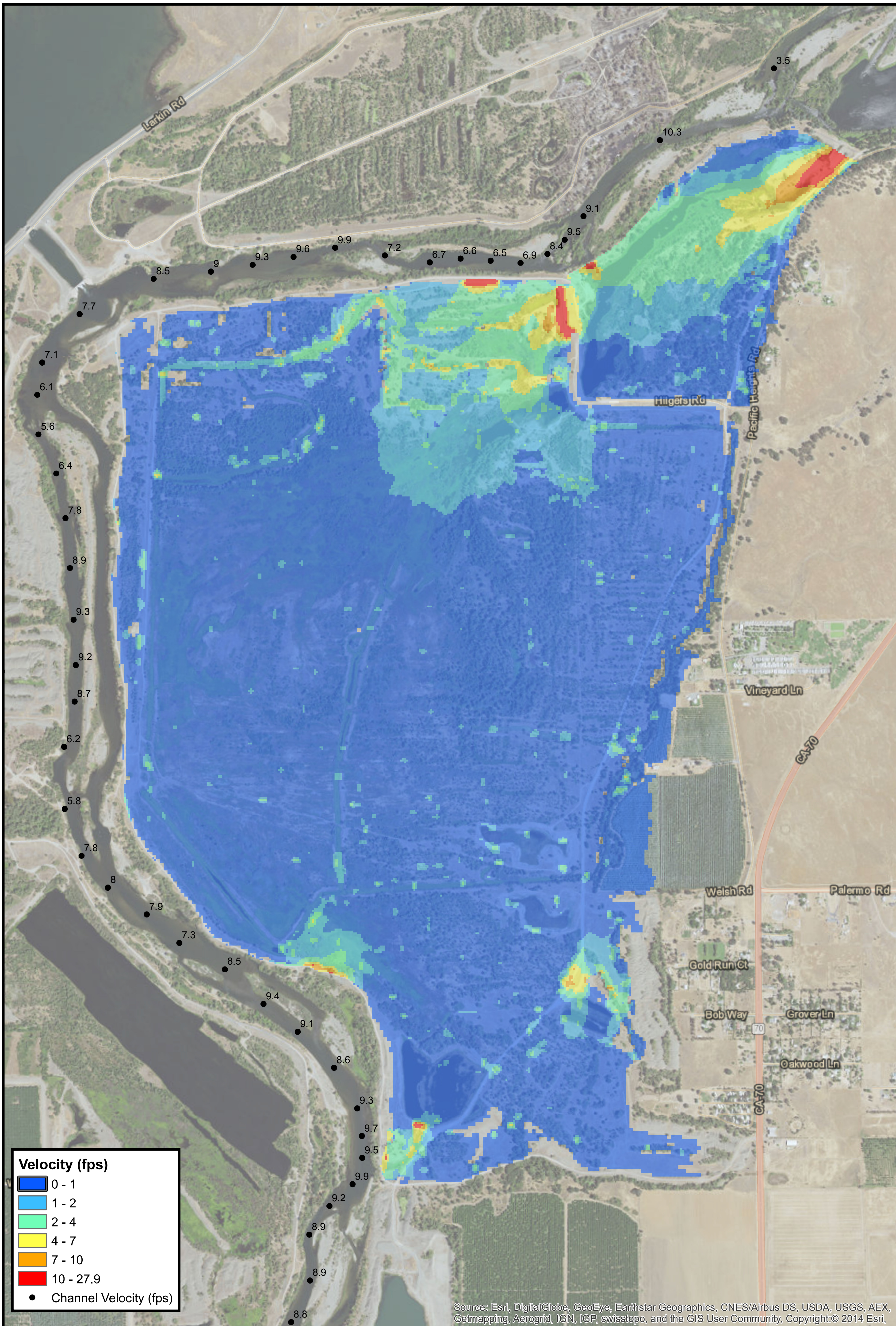
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

0 50 100 Feet

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT
MAX VELOCITIES @ OUTFLOW WEIR

N



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ENGINEERING . CONSULTING

1180 Iron Point Rd., Suite 260
Folsom, CA 95630

Phone: (916) 608-2212
Fax: (916) 608-2232

N

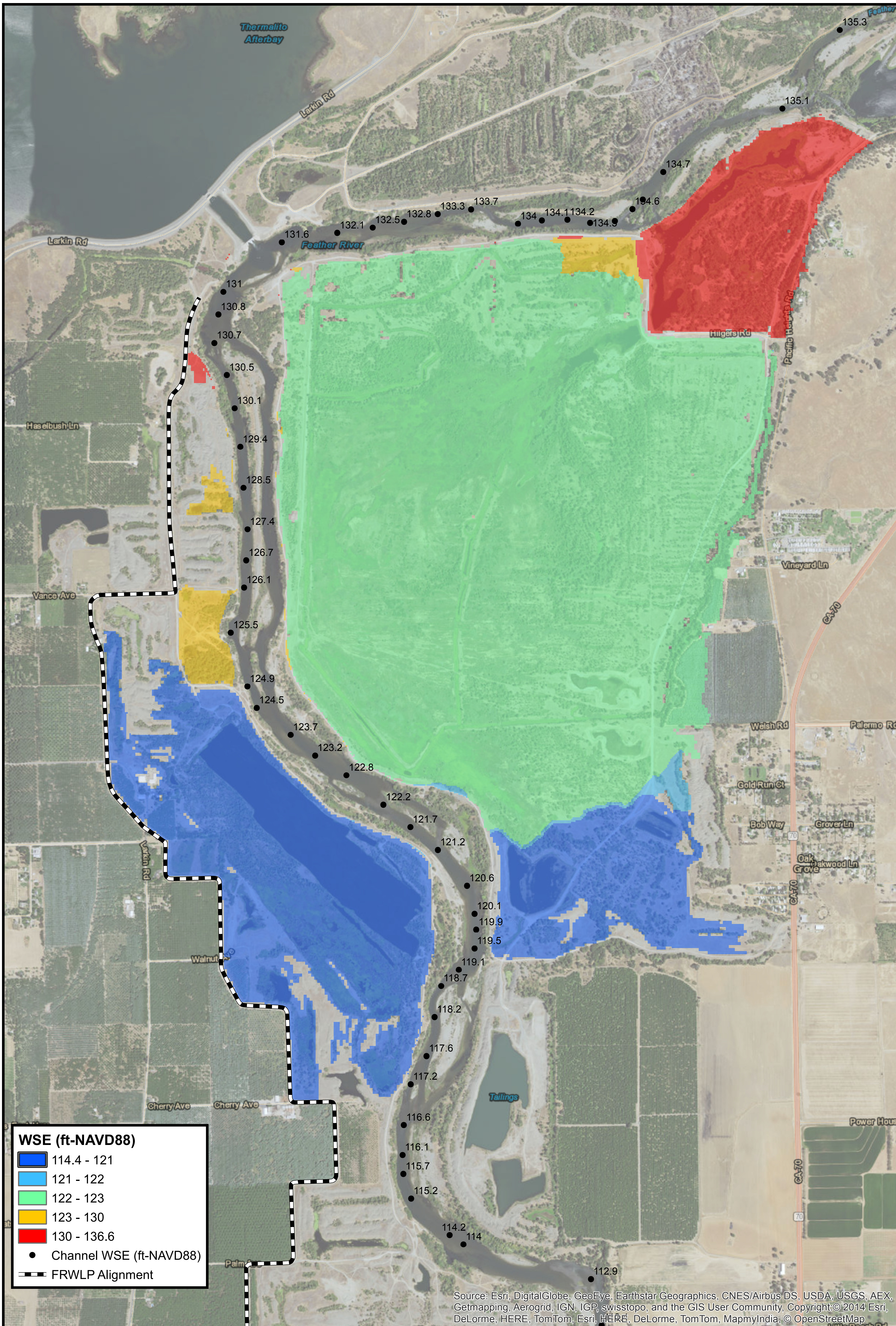
0 1,200 Feet

1 in. = 1,200 ft.

September 29, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT
MAX VELOCITY



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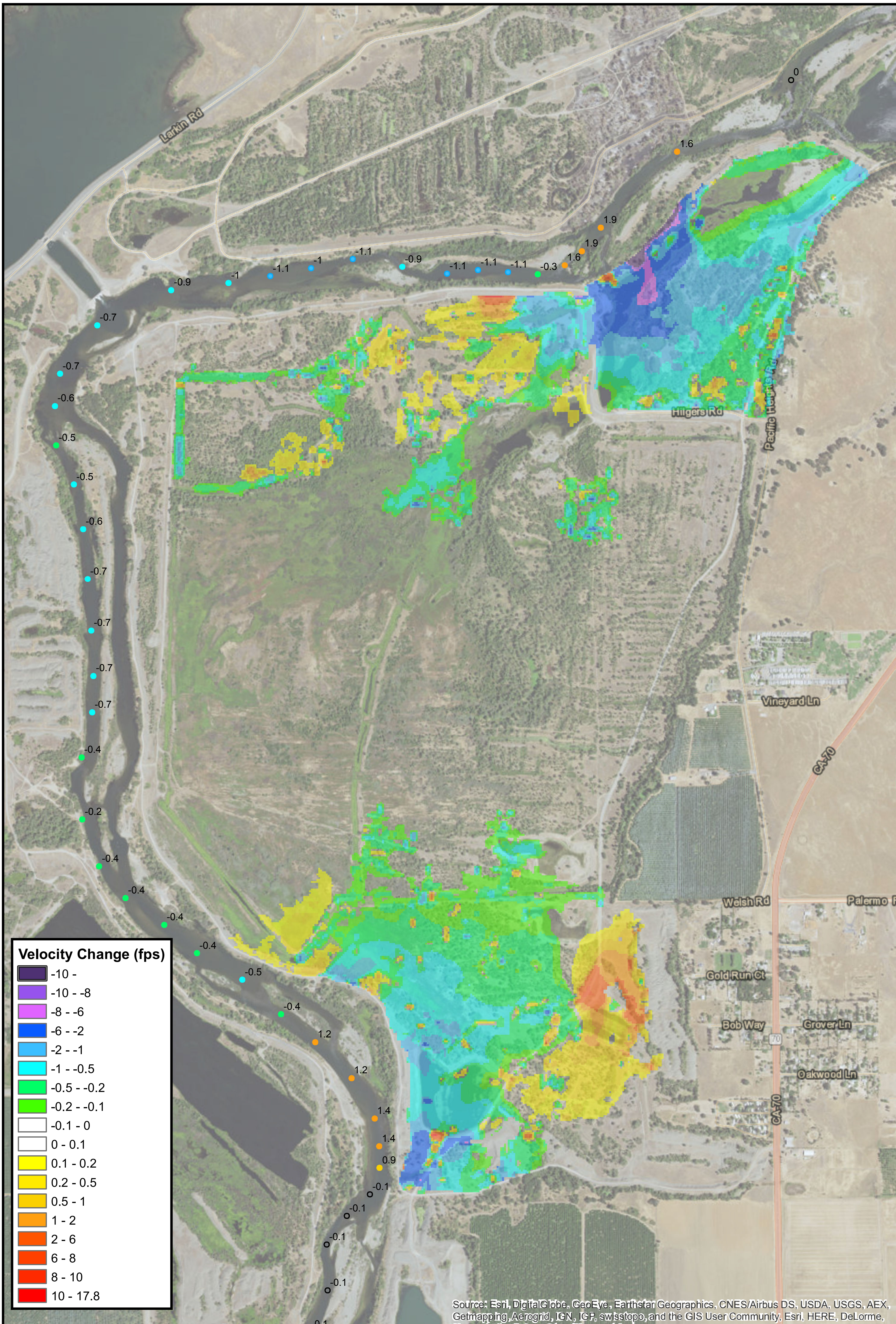
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

N

October 5, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT
MAX WSE



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ENGINEERING . CONSULTING

1180 Iron Point Rd., Suite 260
Folsom, CA 95630

Phone: (916) 608-2212
Fax: (916) 608-2232

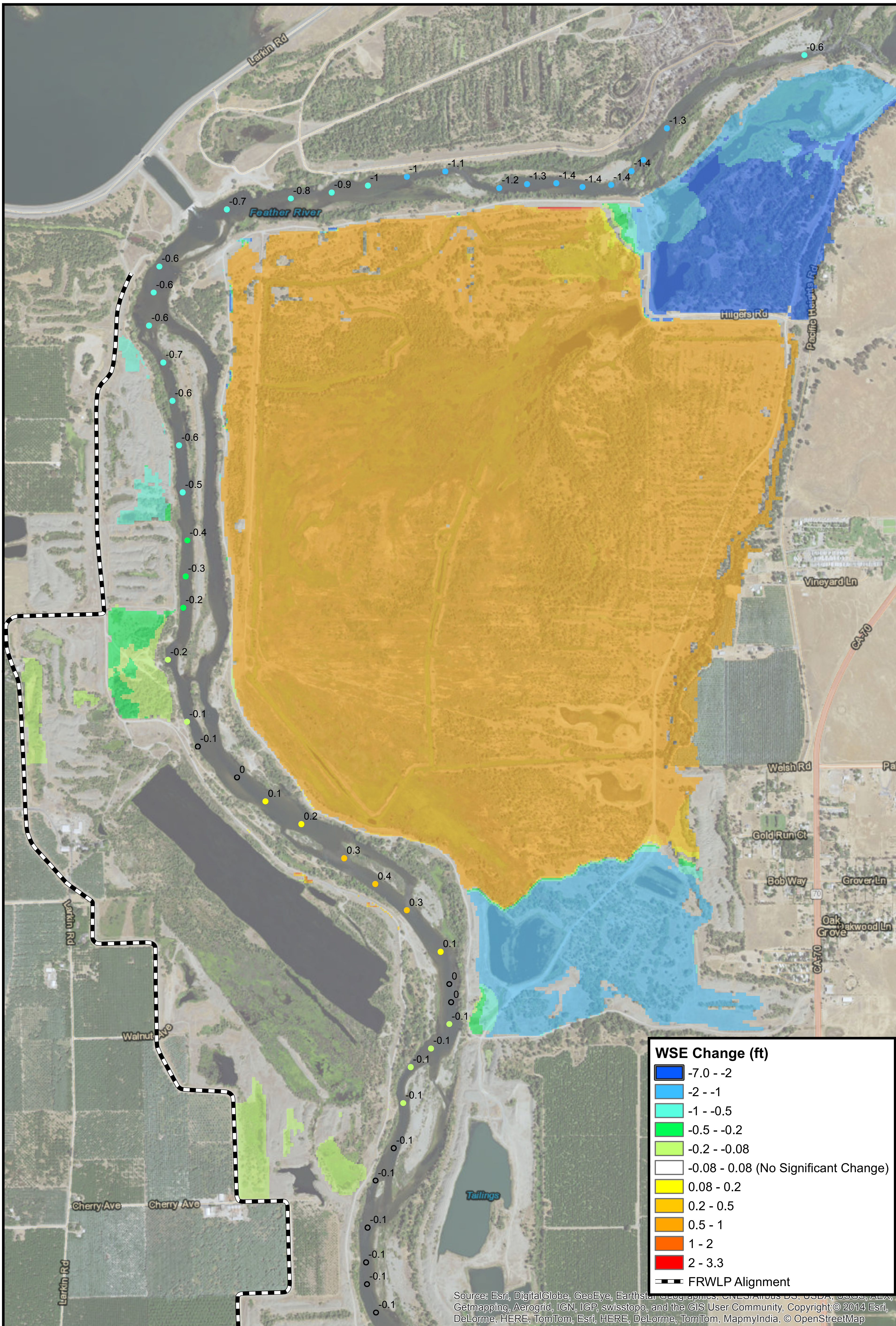
N

0 1,200 Feet

September 11, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT VS. 200-YR BASELINE
VELOCITY CHANGE



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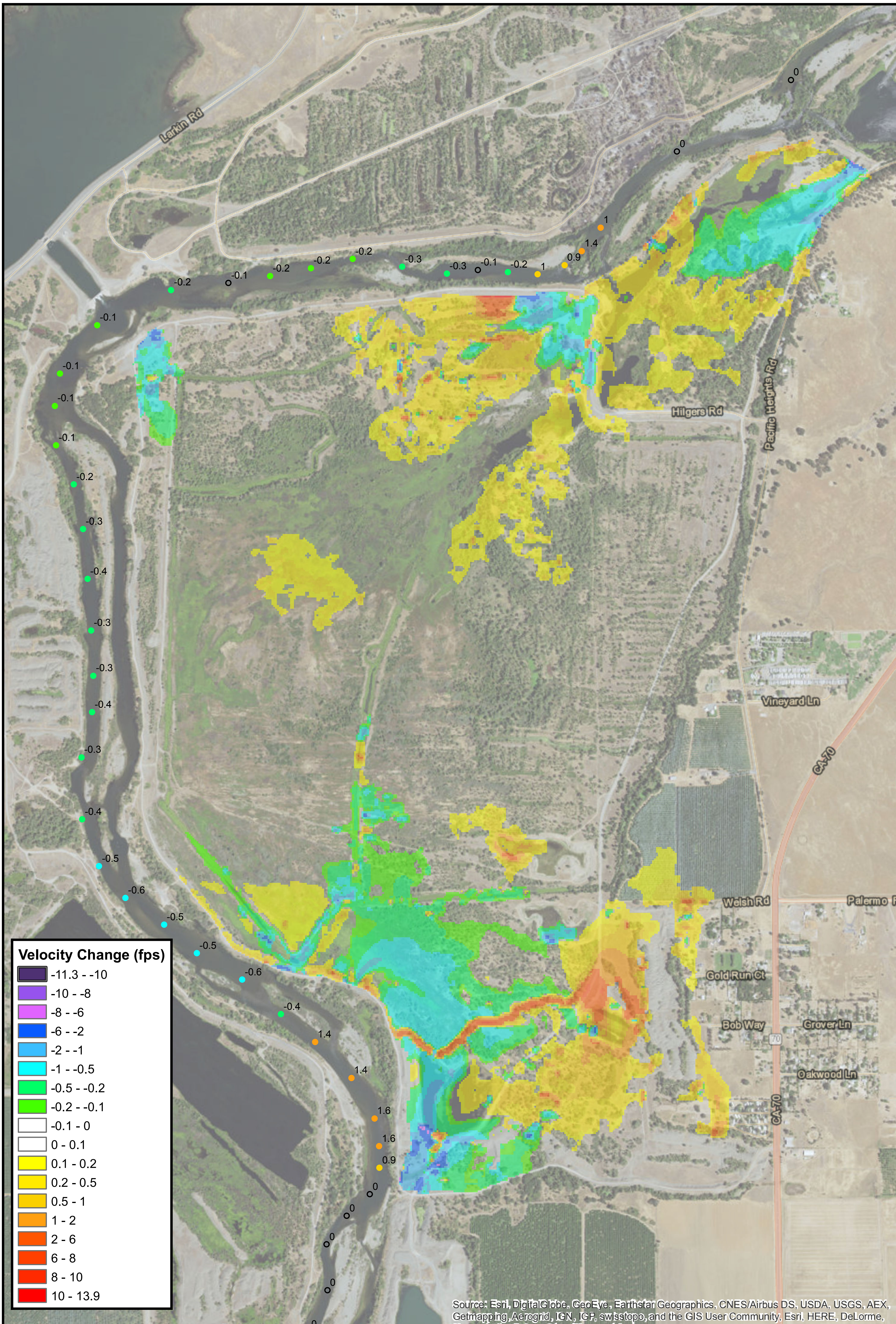
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

October 7, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR WITH-PROJECT VS. 200-YR BASELINE
WSE CHANGE

ATTACHMENT E
1957 DESIGN FLOW WITH-PROJECT RESULTS



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ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

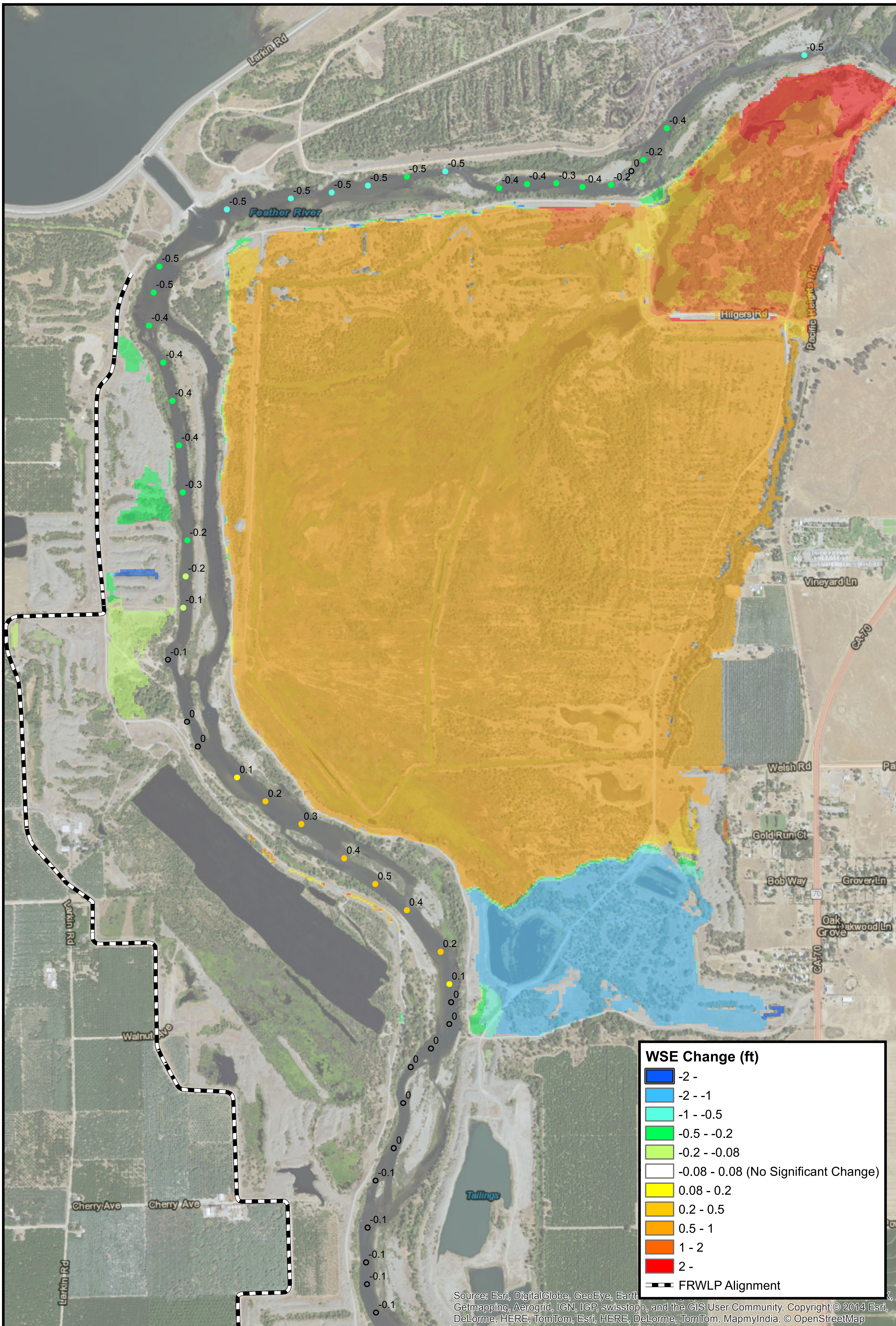
N

0 1,200 Feet

October 2, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
57 DESIGN FLOW WITH-PROJECT VS. 57 DESIGN FLOW BASELINE
VELOCITY CHANGE



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ENGINEERING . CONSULTING

1180 Iron Point Rd., Suite 260
Folsom, CA 95630

Phone: (916) 608-2212
Fax: (916) 608-2232

N

0 — 1,300 Feet

October 22, 2015

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
57 DESIGN FLOW WITH-PROJECT VS. 57 DESIGN FLOW BASELINE
WSE CHANGE

Appendix B. Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Information Request for Inflow Weir Design, January 27, 2016

Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Information Request for Inflow Weir Design

Prepared for: Sutter Butte Flood Control Agency **January 27, 2016**

Prepared by: Vadim Demchuk, EIT
Reviewed by: Chris Fritz, PE, CFM

INTRODUCTION

As part of Sutter Butte Flood Control Agency's (SBFCA) Oroville Wildlife Area (OWA) Flood Stage Reduction (FSR) Project, Peterson Brustad, Inc. (PBI) performed 2-D hydraulic model simulations to document the hydraulic changes associated with the preferred alternative (with-project) conditions[1]. Following that work, the project team (HDR and PBI) progressed further into design and there arose a need to adjust the Manning's n-values in the hydraulic model to better reflect HDR's 35% design plans for the proposed new inflow weir. Additional hydraulic model simulations were then conducted by PBI in order to better understand the anticipated maximum shear stresses and velocities for the 200-year design flow event at the location of the new weir.

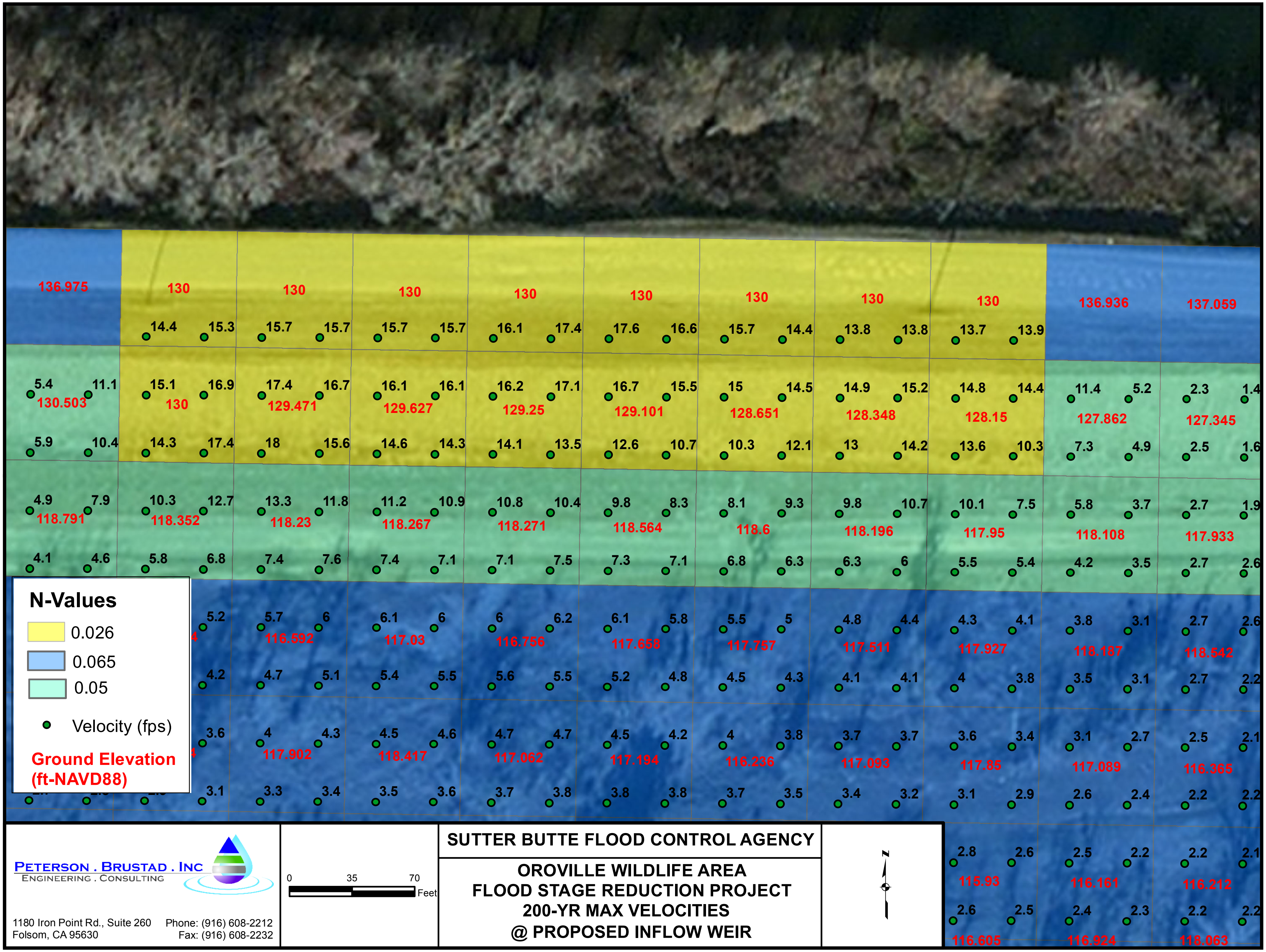
For the analysis, the n-values for the 2-D grid at the location of the new inflow weir were adjusted to better reflect the locations of the new rock gabion baskets, as identified in the 35% design plans.

After incorporating the above the changes into the TUFLOW model, the peak 200-year velocity is shown to be ~18 feet per second and the peak 200-year shear stress is shown to be ~6 pounds per square foot at the location of the proposed new inflow weir. There were no significant changes to water surface elevations or to the overall flow through the weir as a result of the changes. Figures showing the 200-year max velocities and shear stresses are included in Attachment A.

The TUFLOW model files associated with this simulation are named 'OWA_50ft_200yr_025c'. The naming scheme references grid size, n-year event, and run number.

[1] *Oroville Wildlife Area Flood Stage Reduction Project: Hydraulic Analysis for With-Project Conditions*, Peterson Brustad, Inc., December 2015

ATTACHMENT A
200-YEAR MODELING RESULTS
AT THE PROPOSED NEW INFLOW WEIR



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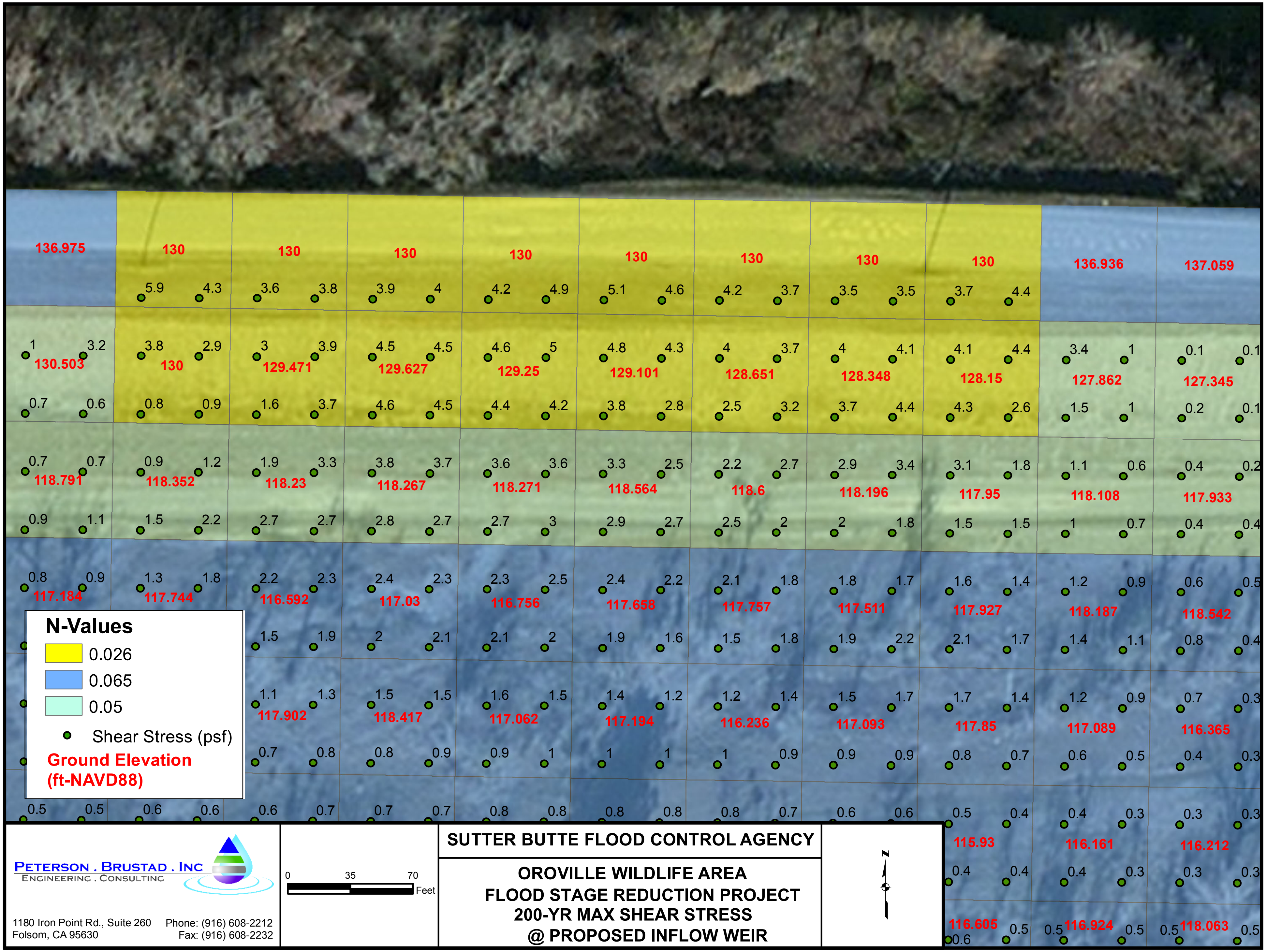
ENGINEERING . CONSULTING
1180 Iron Point Rd., Suite 260
Folsom, CA 95630
Phone: (916) 608-2212
Fax: (916) 608-2232

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR MAX VELOCITIES
@ PROPOSED INFLOW WEIR



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ENGINEERING . CONSULTING

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Folsom, CA 95630

Phone: (916) 608-2212
Fax: (916) 608-2232

0 35 70 Feet

SUTTER BUTTE FLOOD CONTROL AGENCY

OROVILLE WILDLIFE AREA
FLOOD STAGE REDUCTION PROJECT
200-YR MAX SHEAR STRESS
@ PROPOSED INFLOW WEIR

N

Appendix C. Geotechnical Investigation and Recommendation Technical Memorandum, January 28, 2016

Technical Memorandum

Date:	Thursday, January 28, 2016
Project:	Oroville Wildlife Area Flood Stage Reduction Project, Task Order 15, Amendment 1
To:	Daniel Jabbour
From:	Edwin Woo
Subject:	Geotechnical Investigation and Recommendations

Project Background

The Sutter Butte Flood Control Agency (SBFCA) is undertaking a project to improve flood protection along the Feather River corridor. SBFCA is planning to implement the Oroville Wildlife Area (OWA) Flood Stage Reduction (FSR) Project as part of this overall project. The OWA is located about 5 miles southwest of the Town of Oroville, as shown on the Vicinity Map, Figure 1. The OWA FSR Project consists of weir, culvert, and various grading improvements as well as associated ecosystem restoration, in order to improve the connectivity of the Feather River to its historic floodway, and to reduce flooding stages within the main channel. When high flows occur in the Feather River, water will be diverted from the main channel into the OWA South Unit through a system of inflow and outflow weirs. The OWA would then act as essentially a flood control detention basin to reduce peak stage flows in the main river channel. This project is not explicitly included as part of a specific flood control project that is seeking either accreditation by the Federal Emergency Management Agency (FEMA) or the California Department of Water Resources (DWR) under the Urban Levee Program.

Project Description

An overview of the OWA FSR Project is presented on Figure 2, taken from a figure provided by Peterson Brustad, Inc. (PBI). Much of the OWA FSR Project is still in the planning stages and not all of the project features shown on this figure are included in this study. The project features addressed herein include:

- Parking area grading improvements and construction of new portable restroom facilities in the northwestern portion of the OWA site (referred to as Site 1 on the project plans);
- Construction of an approximately 400-foot long Inlet Weir located in the northeastern portion of the OWA site (Site 2). The weir will be located along the berm that currently separates the main channel from the OWA;
- Parking area grading improvements and a new kayak launch area in the northeastern portion of the OWA site (Site 3);

- Improvements to the Outlet Weir and berm located along the existing steel sheet pile wall at the southern boundary of Field 6 (Site 5). The proposed improvements include the placement of additional rip rap protection, raising berm grades to near the top of the sheet pile wall, and constructing a paved road atop the raised berm. The existing steel sheet pile wall serves as the weir and will remain in place; and
- Two adjacent areas in the southern portion of the OWA site, including grading improvements for a new kayak launch area (Site 6) and parking area grading improvements (Site 7).

Scope of Services

The purpose of our study was to evaluate the geotechnical aspects of the project. The scope of our services included:

- Performing subsurface investigation consisting of exploratory borings, test pits, and laboratory testing, to obtain information on subsurface conditions at the locations of the proposed project features;
- Performing geotechnical analysis in support of the development of a design for the Inlet Weir and the paved roadway of the Outlet Weir;
- Developing and presenting recommendations for earthwork, including subgrade preparation, allowable fill materials, placement and compaction of fill, and suitability of on-site soil for use as fill; and
- Developing and presenting recommendations for the selected gabion design for the Inlet Weir.

Subsurface Exploration and Laboratory Testing

Subsurface exploration consisted of test borings and test pits. Test borings were performed in the Inlet and Outlet Weir areas to obtain information on subsurface conditions at these facilities for engineering analysis and design. Relatively shallow test pits were performed in the other site areas to investigate near surface conditions for the proposed improvements, which include relatively minor grading and construction of surface concrete pads for restroom facilities. Test pits were also performed in the Inlet and Outlet Weir areas to obtain information on near surface soil conditions, to supplement the test boring data.

Prior to performing the subsurface explorations, HDR obtained the required Butte County Environmental Health Division (BCEHD) boring permits and contacted Underground Service Alert (USA) to check for the presence of underground utilities.

Nine test pits, designated TP-01 through TP-09, were excavated to depths of about 2.5 to 3.9 feet. The test pits were excavated by an HDR technician on August 12 and 13, 2015, using a Deere 310J backhoe with a 24-inch wide bucket. Test pits TP-01 and TP-02 were excavated in the Site 1 area (Figure 3), test pits TP-03 and TP-04 were excavated in the Site 2 area (Figure 4), test pit TP-05 was excavated in the Site 3 area (also Figure 4), test pits TP-06 and TP-07 were excavated in the Site 5 area (Figure 5), and test pits TP-08 and TP-09 were excavated in the Site 6 and 7 areas, respectively (Figure 6). The soil encountered in the test pits had a high cobble and gravel content. This made it difficult to excavate the test pits deeper as the cobbles and gravel raveled into the excavations. The test pits were backfilled with the excavated materials and the surface lightly tamped.

Five test borings, designated B-01 through B-05, were drilled to depths of about 31.5 to 51.5 feet. The borings were drilled from August 18 through 20, 2015, using a truck-mounted rig with hollow stem augers. Borings B-01 through B-03 were drilled in the Site 2 area (Figure 4), and Borings B-04 and B-05 were drilled in the Site 5 area (Figure 5). Boreholes were grouted with cement grout upon completion. The test borings were sealed upon completion with cement grout and bentonite chips in accordance with the BCEHD boring permit conditions.

An HDR engineer observed the test pit and drilling operations and logged the soil encountered. Recovered soil samples were visually examined and classified in accordance with the Unified Soil Classification System (USCS) and ASTM D2488 (visual method). Soil samples were transported to our office for further examination and selected samples were delivered to a geotechnical laboratory for testing. Logs of the test pits and test borings are included in Appendix A.

Laboratory tests consisting of moisture content, gradation, and Atterberg limits, were performed on selected soil samples retrieved from the borings. The results of the laboratory testing are presented on the boring logs at the appropriate sample depths and/or included in Appendix B.

Site Conditions

The OWA is located in an area that was disturbed by historical dredge mining activity. The proposed site improvements are all located on or adjacent to the perimeter berm that encircles the OWA. The non-engineered berms have been formed using onsite predominantly granular materials. The site areas are unpaved and are elevated above the river and interior of the OWA. Along the berm, and adjacent roadway and clearing areas, the exposed material generally consists of cobbles and gravel, mixed with varying amounts of sand, silt and clay, with little to no vegetation. Tall grasses are present on much of the berm slopes. Other adjacent areas that have not been cleared are generally covered with tall grasses, shrubs and trees.

Existing site grades in the proposed improvement areas are summarized as follows. Elevations in this document are referenced to North American Vertical Datum, 1988 (NAVD88), which is the Project Datum.

- Site 1 – Site grades in the proposed parking area range from about Elevation 130 to 134 feet;

- Site 2 – Site grades in the proposed Inlet Weir area range from about Elevation 136 to 137 at the top of the existing berm, down to about Elevation 117 feet on the landside (OWA side) of the berm;
- Site 3 – Site grades in the proposed parking and grading improvement areas range from about Elevation 121 down to about Elevation 110 feet at the end of the proposed kayak launch;
- Site 5 – Site grades in the proposed Outlet Weir Improvement area range from about Elevation 108 to 124 feet at the top of the existing berm, down to about Elevation 105 feet at the OWA and riverside limits of the proposed improvement area. An approximately 500-foot long steel sheet pile wall extends along the southern (riverside) edge of the berm roadway. Construction details, including the depth of the wall, are not currently known. The depth to which this wall extends is not known to us. The top of the wall tilts toward the riverside of the berm. Rip rap covers the riverside slope below the wall to the toe of the berm;
- Site 6 – Site grades range from about Elevation 113 feet at the higher portion of the proposed grading improvement area near the berm, down to about Elevation 95 feet at the end of the proposed boat launch; and
- Site 7 – Site grades range from about Elevation 115 to 125 feet in the proposed parking area.

Subsurface Conditions

At Site 1, the soil encountered in Test Pits TP-01 and TP-02 generally consists of cobbles and gravel, with sand and silt, to the maximum depth explored of about 2.8 feet. Hard digging was encountered through the entire depth of excavation.

At Site 2, Borings B-01 and B-02 were drilled from the top of the berm and Boring B-03 was drilled beyond the toe of the berm. The soil encountered in about the upper 22, 29, and 7 feet, in Borings B-01, B-02, and B-03, respectively, generally consists of a mix of cobbles, gravel, sand, silt, and clay. This suggests that the berm itself and the upper portion of the adjacent landside area (7 feet at Boring B-03) are comprised of this material. Standard Penetration Test (SPT) blow counts indicate that the density of the material varies greatly, ranging from loose to very dense. Due to relatively small size of the sampler and sampling method relative to the relatively large sized cobbles present, approximations of material density from the SPT blow counts is likely to be inaccurate and may only provide a qualitative estimate of material density. Test Pits TP-03 and TP-04 were excavated near Borings B-01 and B-02, respectively, and encountered similar materials within the shallow depths explored (to 3.3 feet). Hard digging was encountered through the entire depth of excavation.

At Site 3, the soil encountered in Test Pit TP-05 generally consists of cobbles and gravel, with sand, to a depth of about 2 feet. Hard digging was encountered through this depth. Below 2 feet, sand with gravel was encountered to the depth explored of about 3.7 feet.

At Site 5, Borings B-04 and B-05 were drilled from the top of the berm. The soil encountered in about the upper 19.5 and 27 feet, in Borings B-04 and B-05, respectively, generally consists of a mix of cobbles, gravel, sand, silt, and clay. This suggests that the berm itself and the upper portion of the adjacent landside area are comprised of this material. Standard Penetration Test (SPT) blow counts indicate that the density of the material varies greatly, ranging from loose to very dense. Due to relatively small size of the sampler and sampling method relative to the relatively large sized cobbles present, approximations of material density from the SPT blow counts is likely to be inaccurate and may only provide a qualitative estimate of material density. Test Pits TP-06 and TP-07 were excavated near Borings B-04 and B-05, respectively, and encountered similar materials within the shallow depths explored (to 3.5 feet). Hard digging was encountered through the entire depth of excavation.

At Site 6, the soil encountered in Test Pit TP-08 generally consists of cobbles and gravel, with sand, to the depth explored of about 3.9 feet. Hard digging was encountered through the entire depth of excavation.

At Site 7, the soil encountered in Test Pit TP-09 generally consists of cobbles and gravel, with sand and silt, to the depth explored of about 2.8 feet. Hard digging was encountered through the entire depth of excavation.

The depth to groundwater could not be established in the borings at the time of drilling. Due to difficult drilling conditions, water had to be added into the auger in some of the borings to prevent sand blow out, obscuring the ability to determine water level. Test Pit TP-05 was excavated in Site 3, just above river level. Water was observed to be seeping into the test pit at a depth of 3.3 feet, which corresponded to the approximate river level at the time of excavation. Given the site locations and the relatively high permeability of the underlying soil, we expect that groundwater levels in the proposed improvement areas correspond closely with water levels in the river.

Fluctuations in the groundwater level could occur due to changes in seasons, variations in rainfall, and other factors.

Analyses and Conclusions

Inlet Weir

Working with PBI, the HDR team developed a concept for the Inlet Weir. The concept consisted of lowering the existing berm grades to Elevation 130 feet and constructing a rock gabion-type weir structure. PBI performed hydraulic modeling to estimate flow velocities and shear stresses over a gabion-lined weir with a crest width between 50 and 100 feet. Hydraulic modeling was performed for the following case, which was taken as the design case: a 200-year event with a peak flow of 15,000 cubic feet per second (cfs) over the weir, with no Permanent Connection. The Permanent Connection refers to another outlet structure being considered to the west of the Outlet Weir in the southern portion of the OWA. Based on the PBI hydraulic modeling, typical flow velocities over the weir range from about 10 to 17 feet per second (fps), and typical shear stresses range from about 1 to 6 pounds per square foot (psf).

A conceptual gabion-lined weir design was developed and evaluated to assess its ability to resist these flow velocities and shear stresses. These are the two key parameters to evaluate for determining the suitability of using gabions in this type of application. A schematic of this gabion weir concept was shared with the HDR team on October 29, 2015, and is presented herein as Figure 7. The concept consists of an 18-inch thick gabion mattress over the top and landside slope of the berm, and extending out 50 feet beyond the berm toe as an apron. The system also includes gabion baskets (3 feet by 3 feet) at the slope transition points (see Figure 7).

Published sources were reviewed to estimate the acceptable velocity and shear stress limits for design. For velocity, two limit levels are considered: critical and limit velocity. Critical velocity is defined as the velocity at which the gabion mattress will remain stable without movement of the stone fill; limit velocity is defined as the velocity at which there is some deformation (but not failure) of the gabion mattress due to movement of the stone fill. These limits are summarized below, for the type and size of gabion system being considered:

For Velocity

Reference	Allowable Velocities for Design (fps)
Freeman and Fishenich, Gabions for Streambank Erosion Control, ERDC TN-EMRRP SR-22, adapted from Maccaferri Gabions (May 2000)	19 to 21 (critical velocity) 24.9 to 26.2 (limit velocity)
FEMA, Technical Manual: Overtopping Protection for Dams, FEMA P-105 (May 2014)	24 to 30

For Shear Stress

Reference	Allowable Shear Stresses for Design (psf)
Freeman and Fishenich, Gabions for Streambank Erosion Control, ERDC TN-EMRRP SR-22, adapted from Maccaferri Gabions (May 2000)	About 4
FEMA, Technical Manual: Overtopping Protection for Dams, FEMA P-105 (May 2014)	35

Based on the PBI hydraulic modeling, typical flow velocities over the weir range from about 10 to 17 feet per second (fps). These values are below both the critical and limit velocity values presented in published sources. We judge that the proposed gabion weir concept is acceptable from the perspective of resisting the design flow velocities.

Based on the PBI hydraulic modeling, typical shear stresses range from about 1 to 6 pounds per square foot (psf). These values are below or slightly above the limit presented by Freeman and Fishenich, but well below the allowable limit presented by FEMA. An effort was made to resolve the large discrepancy in the allowable shear stresses presented in these two references. A discussion was found in another reference by FHWA (Hydraulic Engineering Circular No. 15, Third Edition, Design of Roadside Channels with Flexible Linings, September 2005) that the 4 psf limit was developed based on research by Simons et al (1984) and the 35 psf limit was developed based on research by Clopper and Chen (1988). FHWA suggested that the difference may be explained by their respective definitions of failure. FHWA indicated that Simons suggested that the allowable shear stress should be limited to a value that would only result in some deformation of the gabions, comparable to the performance established for limit velocities. Clopper and Chen established their shear stress limit of 35 psf based on what would cause the stones to shift downslope to one end of the basket.

We judge that the Clopper and Chen criterion is too lenient for the Inlet Weir performance objectives. Some of the shear stress values estimated by PBI are above the 4 psf limit presented by Simons, Freeman and Fishenich and others. This may result in some deformation of the gabion mattress at these locations with higher shear stresses. If this is acceptable, we judge that the proposed gabion concept can be used. The lateral extents of the gabions should be determined by the hydraulic design team to account for flow spreading as the water passes over the top of the weir.

We also performed steady-state seepage and stability analysis of the proposed Inlet Weir as part of our evaluation. The results of these analyses are presented in Appendix C. From the seepage analysis, we estimate that the flow through the berm is less than 2 cfs over the 400-foot length of the weir for the critical case where the water level is set at the crest. This is a negligible quantity of flow compared to the 15,000 cfs over the weir that was modeled by PBI. This analysis confirms that PBI's assumption for their model of having flow only over the weir is valid. Stability analysis was performed for the steady-state condition of having the riverside water level set right at the top of the weir, judged to be the critical condition. Relatively conservative soil parameters were selected for the analysis model. The results of the analysis show that the proposed Inlet Weir has an adequate factor of safety for stability.

Outlet Weir and Road

The proposed improvements to the existing sheet pile weir include the placement of additional rip rap protection on both the landside and riverside of the weir and the construction of a paved road atop the raised berm. PBI performed hydraulic modeling to estimate flow velocities and shear stresses over the Outlet Weir. As for the Inlet Weir, hydraulic modeling was performed for the 200-year event with no Permanent Connection scenario. Based on the PBI hydraulic modeling, typical flow velocities over the Outlet Weir range from about 4 to 14 fps, and typical shear stresses range from about 1 to 8 psf. However, the model resulted in shear stresses as high as about 21 fps in one area near the center of the weir. Given the relatively high shear stresses, and since the roadway will need to serve as the top of the weir, the roadway should consist of material with relatively high erosion resistance. We conclude that the roadway should consist of a concrete pavement. Concrete pavement section recommendations are presented below.

Parking Areas, Grading Improvement Areas and Restrooms

As described above, earthwork consisting of grading, subgrade preparation, and the placement and compaction of fill, will be performed at several locations for parking areas and for grading improvements. Grading and subgrade preparation will also be performed for new concrete pads for restroom facilities. Earthwork recommendations are presented below for these proposed improvements.

Recommendations

Site Preparation

The sites of the proposed improvements should be cleared of vegetation and obstructions. Excavated material may be reused as fill, provided it is broken up to meet the requirements described below under *Engineered Fill Materials*. Holes resulting from the removal of underground obstructions extending below the proposed pavement subgrade should be cleared and backfilled with suitable material compacted to the requirements described below under *Fill Placement and Compaction*.

Subgrade Preparation

Following excavation to the required grades, the top 6 inches of subgrade in areas to receive fill (including gravel for gravel roadway areas), concrete slabs for restrooms, and gabion mattresses/baskets should be scarified, moisture conditioned and compacted to at least 95 percent of the soil's maximum dry density. Areas of weak or unstable soil should be overexcavated to competent soil, or a minimum of 18 inches below finished subgrade elevation where competent soils are not encountered. The compacted surface should be firm and unyielding and should be protected from damage caused by traffic or weather. Soil subgrades should be kept moist during construction. In order to achieve satisfactory compaction of the subgrade materials, the water content may need to be adjusted at the time of construction. This may require that water be added to soils that are too dry, or that scarification and aeration be performed in any soils that are too wet.

In areas that are to receive fill where the resulting subgrades are steeper than 6:1 (horizontal to vertical), keyways should be constructed at the bottoms of the slopes and benches should be constructed up the slopes. Keyways should extend a minimum of 3 feet below existing grades. The bottoms of keyways should be level and have a minimum width of 12 feet. Benches should have a maximum step height of 3 feet.

It is noted that much of the exposed subgrade surfaces may consist of cobble-sized material, making scarification and moisture conditioning difficult. Density testing of such materials may also be difficult. For such conditions, compaction with at least four passes with a heavy roller compactor should be performed in lieu of scarification and compaction, to provide a firm and unyielding surface.

Engineered Fill Materials

All soil fill placed at the site should consist of engineered fill meeting the requirements presented in this report. On site soil having no visible concentration of organic material, and free of debris and other deleterious materials, can be reused as fill. All engineered fill placed at the site, including on-site soil, should not contain rocks or lumps larger than 6 inches in greatest dimension and contain no more than 15 percent larger than 2.5 inches. Based on the soil encountered in the subsurface explorations, much of the on site soil consists of relatively large cobbles that are larger than 6 inches in size. Sorting and culling of the on site soil may be required in order to get backfill of suitable size and size distribution for proper placement and compaction. High moisture content soils that meet these requirements are not considered as unsuitable material but will require proper moisture conditioning prior to placement and compaction.

Imported fill should be predominantly granular, meet the size requirements presented above, have no visible concentration of organic material, should have a liquid limit less than 40 percent, have a plasticity index not exceeding 15, should be non-corrosive, and should contain no environmental contaminants or debris.

Recommendations for stone fill for the gabion mattresses and baskets are presented below.

Fill Placement and Compaction

Engineered fill should be compacted to at least 95 percent relative compaction as determined by ASTM D698, latest edition. The top 6 inches of subgrade in areas to receive gravel roadways and concrete slabs should be moisture conditioned and compacted to at least 100 percent relative compaction. Fill that will have a final compacted thickness of greater than 5 feet should be entirely compacted to at least 100 percent relative compaction. Fill material should be spread and compacted in lifts not exceeding eight inches in uncompacted thickness. In order to achieve satisfactory compaction of fill materials, the water content may need to be adjusted at the time of construction. This may require that water be added to soils that are too dry, or that aeration be performed in any soils that are too wet.

Gabion-Lined Inlet Weir Structure

We recommend that the Inlet Weir be designed as a gabion-lined structure. The design should be based on the concept described above under Analysis and Conclusions, and presented on Figure 7. The concept consists of an 18-inch thick gabion mattress over the top and landside slope of the berm, and extending out at least 50 feet beyond the berm toe as an apron. The apron can be extended further beyond the toe if necessary, based on other design requirements such as hydraulics. The system also includes gabion baskets (3 feet by 3 feet) at the slope transition points.

We anticipate that the on site cobbles will be used as stone fill for the gabion mattresses and baskets. Gabion stones should be between 4 to 8 inches in diameter with an average stone size (D_{50}) of 6 inches. The fabrication and installation of the mattresses and baskets, and placement of the stone fill, should be performed in accordance with the gabion manufacturer's recommendations.

Outlet Weir Roadway

We recommend that the Outlet Weir roadway consist of a rigid or concrete pavement section. We developed the following pavement sections based on Chapter 620 of the State of California Department of Transportation Highway Design Manual (Caltrans HDM). Based on this procedure, the rigid pavement section is determined based on the following parameters: subgrade soil type, climate region in which the site is located, and traffic index (TI).

For rigid pavement design, Caltrans groups soil subgrades into three types: Type I soil has an R-value > 40, Type II soil has an R-value between 10 and 40, and Type III has an R-value less than 10. Given the high cobble and gravel content of the on-site soil, we judge that the on-site subgrade consists of Type I soil. The site is located in the Inland Valley climate region, based on its location.

We have developed the following pavement design recommendation based on its subgrade condition, climate region, and a TI of less than or equal to 9.0 (the lowest category). On this basis, we recommend that the Outlet Weir roadway rigid pavement section can consist of 9 inches of jointed plain concrete pavement (JPCP) over 6 inches of Aggregate Base. This pavement section assumes that lateral support is provided along both edges of the roadway. If lateral support is not provided, the concrete thickness should be increased to 9.5 inches.

Rigid pavements should have dowels and tie bars as outlined in Chapter 620 of the Caltrans HDM. The Aggregate Base for use in rigid pavements should conform to Caltrans Standard Specification Section 26-1.02A for Class 2 Aggregate Base. The Aggregate Base used in the pavement sections should be compacted to 100 percent of the soil's maximum dry density (ASTM D698) and should be firm and unyielding at the time of concrete placement.

Limitations

This memorandum has been prepared for the use of the Sutter Butte Flood Control Agency and its consultants for specific application to this project in accordance with generally accepted geotechnical engineering practice. No warranty, express or implied, is made. The analyses and recommendations submitted are based on the data available to HDR at the time of this geotechnical investigation and on the data collected during the field investigation. This report does not reflect subsurface soil variations that may occur between the locations of the explorations or variations in groundwater conditions which may occur over a period of time. Variations in conditions may become evident during construction, at which time re-evaluation of the conclusions may become necessary. In the event of design changes in the project after the final report is submitted, the recommendations should be reviewed and possibly modified with

HDR's participation. The proposed improvements are intended to allow for inlet and outlet of peak river flows into the OWA. The improvements are not intended to be a critical improvement to an existing flood control project and therefore, not subject to the requirements or the standard of care required for obtaining FEMA accreditation or meeting DWR Urban Levee Design Criteria. Additional studies and recommendations would be required to meet these requirements and standards of care.

Historical explorations and testing were not performed by HDR and HDR cannot vouch for the accuracy of data and information obtained by others. The subsurface data by others are presented herein in an attempt to include data relevant to this project in one document. Data by others should not be relied upon unless the originator of that data is available to confirm its accuracy.

This geotechnical study did not include an investigation regarding the existence, location, or type of possible hazardous materials. If any hazardous materials are encountered during construction of the project, the proper regulatory officials should be notified immediately.

References

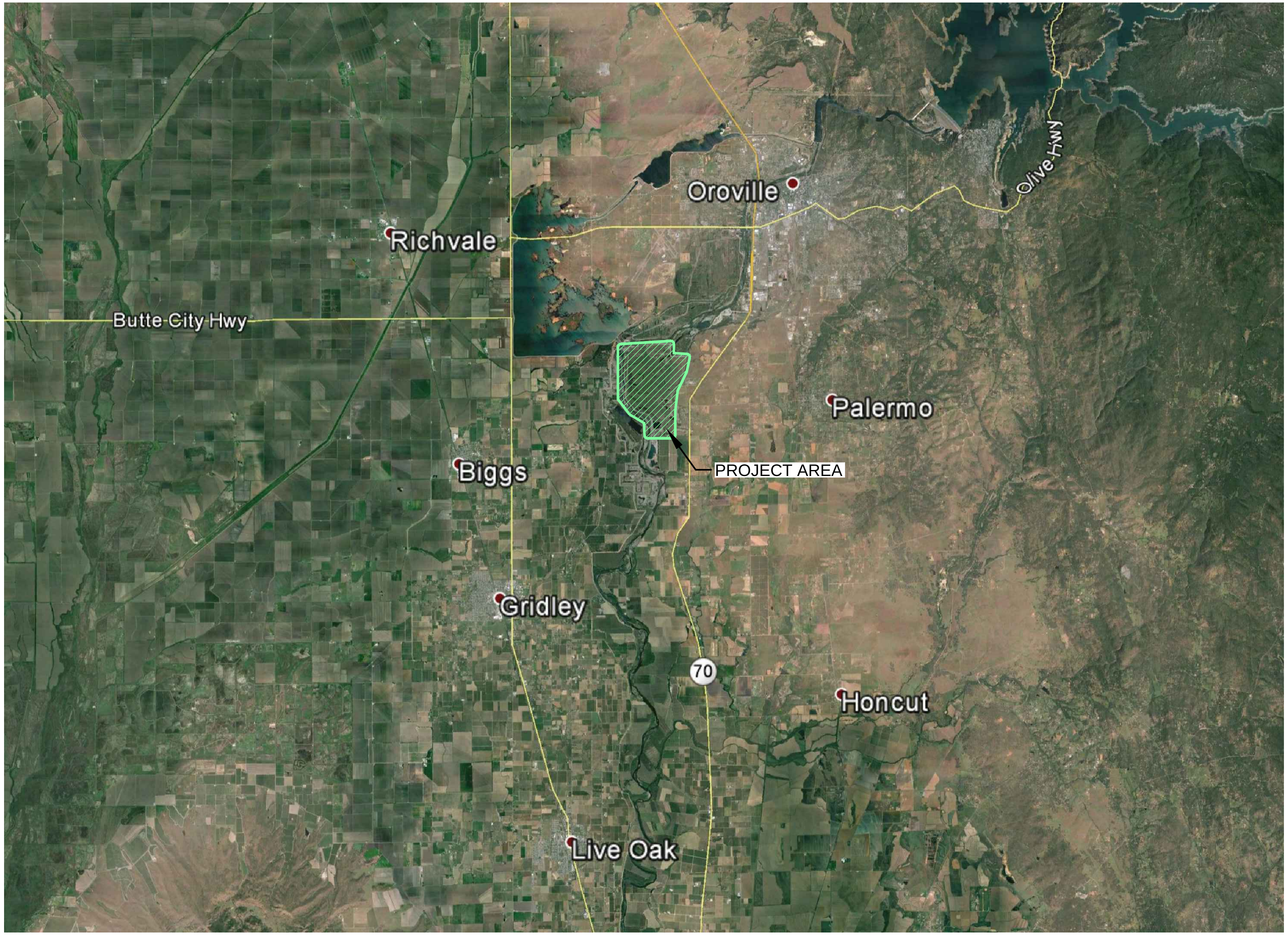
California Department of Transportation (2008), Highway Design Manual, Chapter 620 – Rigid Pavement, July 1.

Federal Emergency Management Agency (2014), Technical Manual: Overtopping Protection for Dams, FEMA P-105, May.

Federal Highway Administration (2005), Design of Roadside Channels with Flexible Linings, Hydraulic Engineering Circular No. 15, Third Edition, September.

Freeman, Gary E. and Fishenich, J. Craig (2000), Gabions for Streambank Erosion Control, ERDC TN-EMRRP SR-22, adapted from Maccaferri Gabions, May.

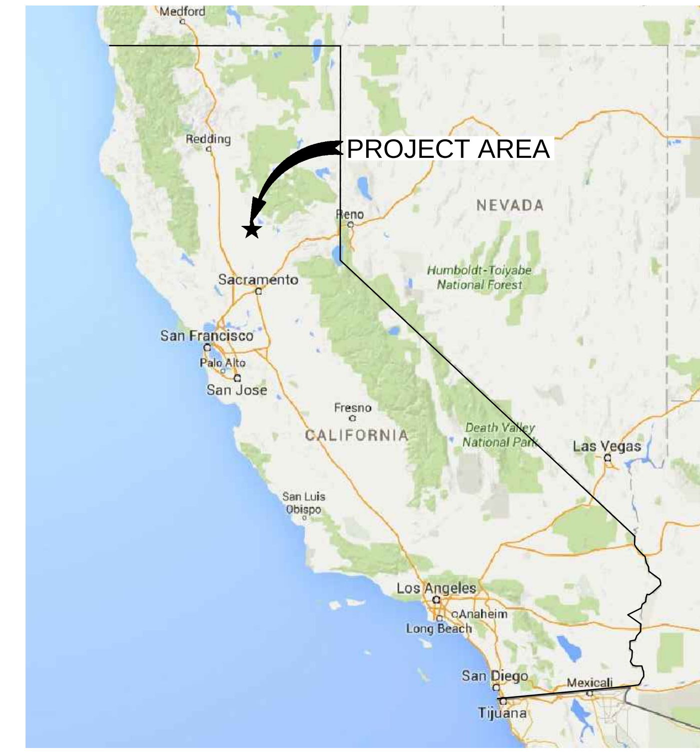
Figures



SOURCE: GOOGLE Earth Pro Aerial Imagery

3 0 3 6

SCALE IN MILES



SOURCE: GOOGLE MAPS

NOT TO SCALE

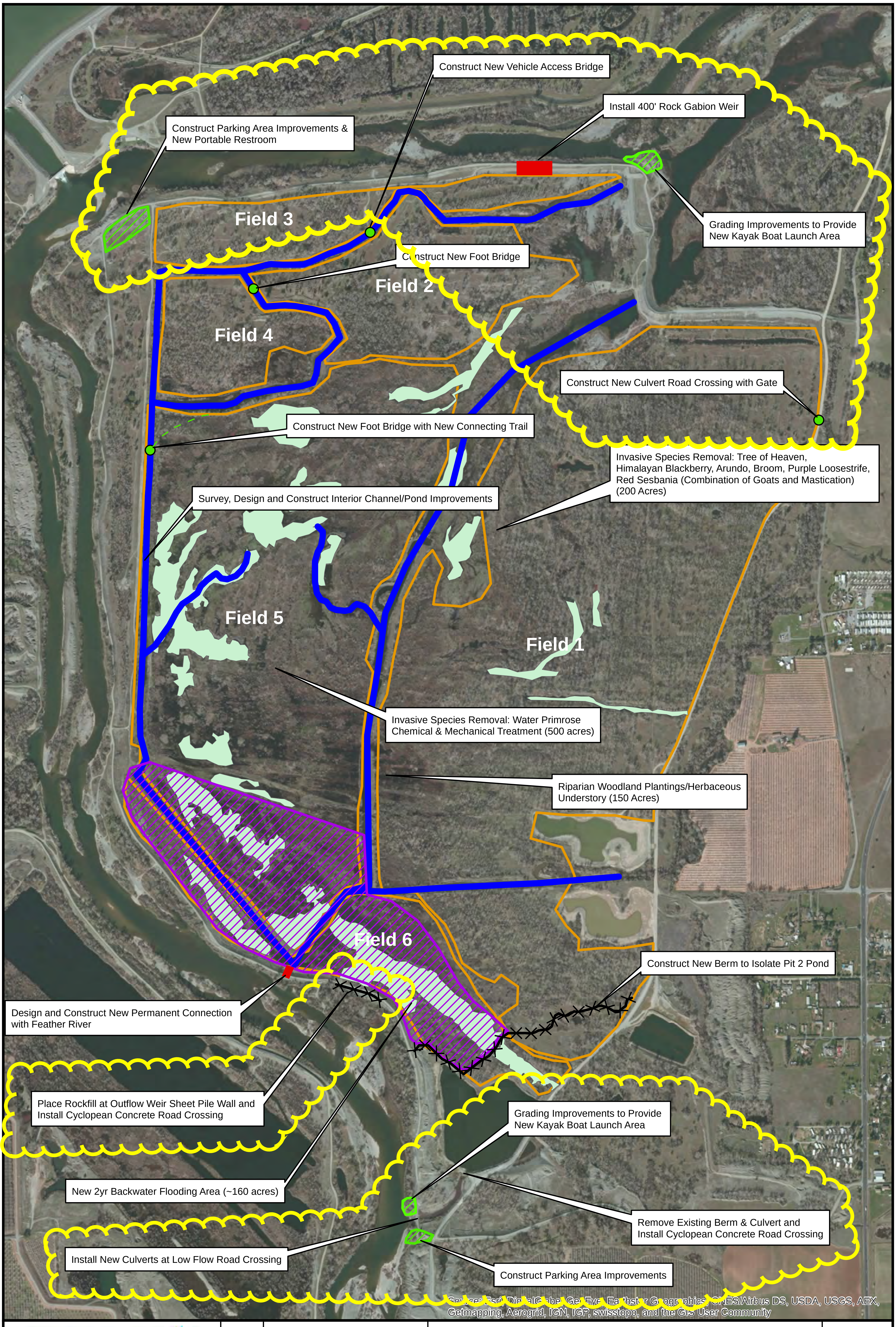
N

VICINITY MAP

OROVILLE WILDLIFE AREA
BUTTE COUNTY, CALIFORNIA

Date
JAN 2016

Figure
1



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SUTTER BUTTE FLOOD CONTROL AGENCY

FIGURE 2

Overview of OWA FSR Project

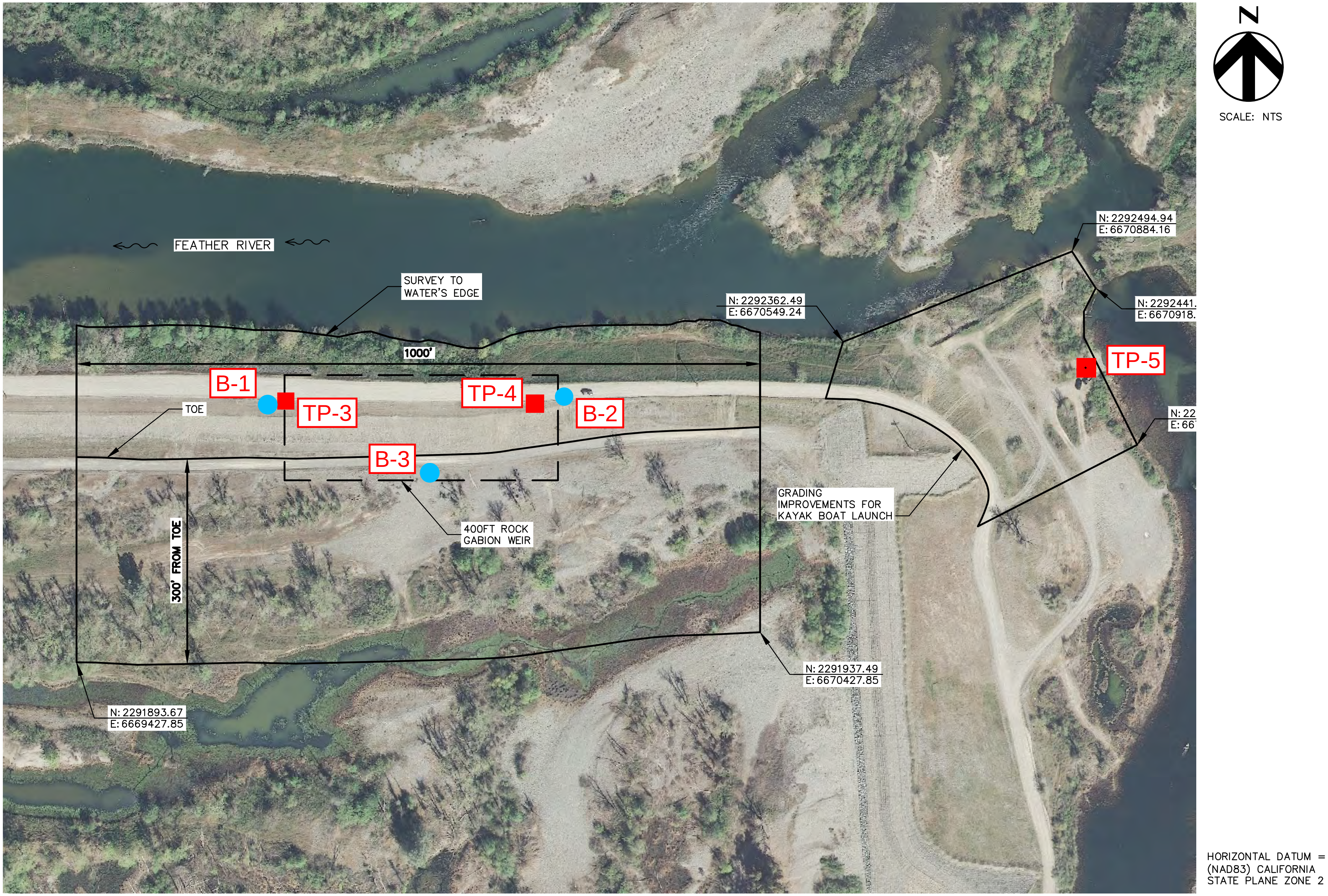
HDR

SUTTER BUTTE FLOOD CONTROL AGENCY
OROVILLE WILDLIFE AREA FLOOD STORAGE REDUCTION PROJECT

IMPROVEMENT LOCATION MAP - SITE 1

DATE
JAN 2016

FIGURE
3



HDR

SUTTER BUTTE FLOOD CONTROL AGENCY
OROVILLE WILDLIFE AREA FLOOD STORAGE REDUCTION PROJECT

IMPROVEMENT LOCATION MAP - SITES 2 AND 3

DATE
JAN 2016

FIGURE
4

HDR

SUTTER BUTTE FLOOD CONTROL AGENCY
OROVILLE WILDLIFE AREA FLOOD STORAGE REDUCTION PROJECT

IMPROVEMENT LOCATION MAP - SITE 5

DATE
JAN 2016

FIGURE
5

N

SCALE: NTS

HORIZONTAL DATUM =
(NAD83) CALIFORNIA
STATE PLANE ZONE 2

HDR

SUTTER BUTTE FLOOD CONTROL AGENCY
OROVILLE WILDLIFE AREA FLOOD STORAGE REDUCTION PROJECT

IMPROVEMENT LOCATION MAP - SITES 6 AND 7

DATE
JAN 2016

FIGURE
6

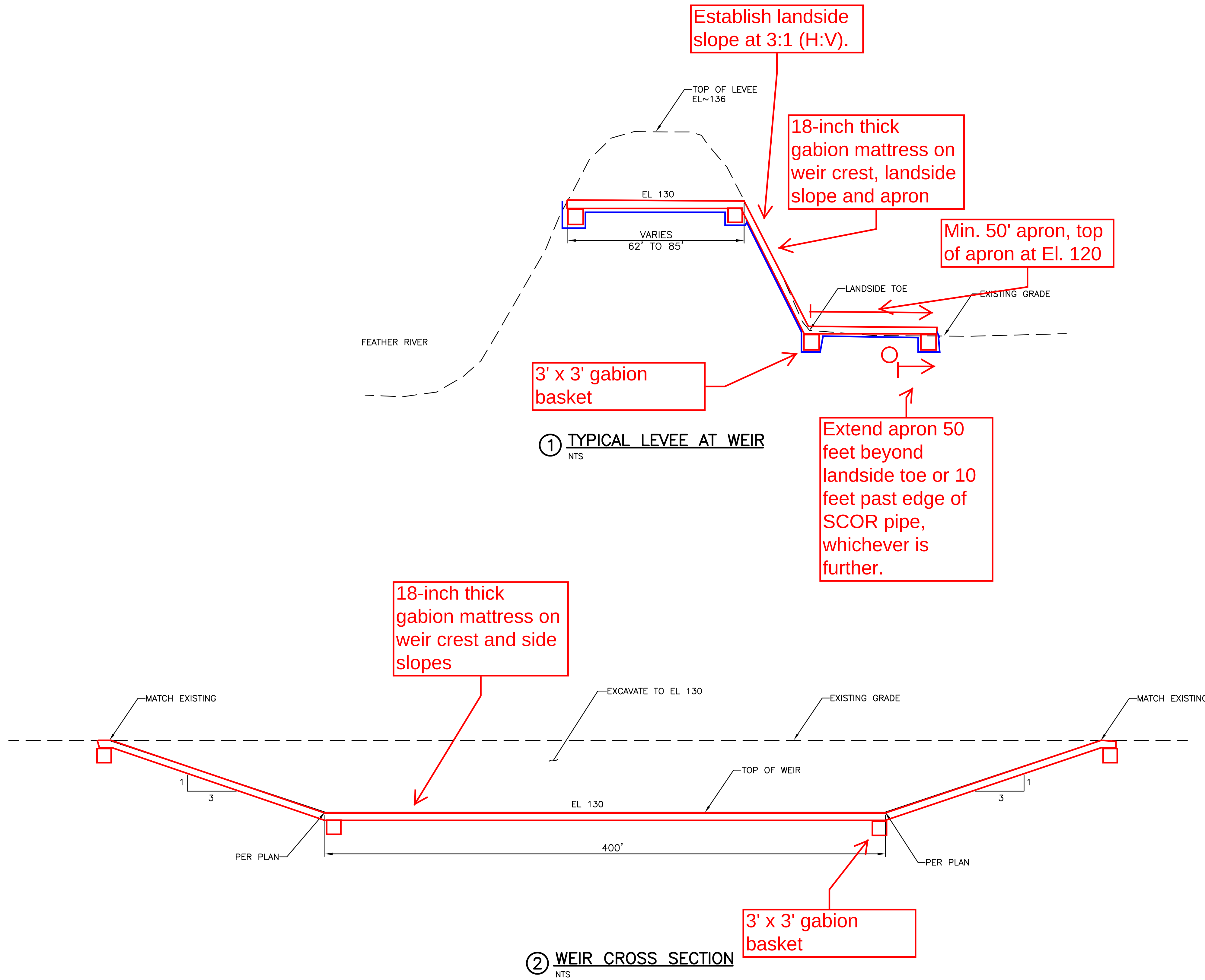


Figure 7

DRAFT

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION
X	X/XX/XX	XX	XX	XX	X

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: J. NETTLETON
DRAWN BY: A. JACKSON
IN CHARGE: D. JABBOUR
PROJECT MANAGER: C. KRIVANEC
DATE: X/X/XXXX

PRELIMINARY

HDR Engineering Inc.
2365 Iron Point Rd. Suite 300
Folsom, CA 95630

SUBMITTED

APPROVED

SUTTER BUTTE FLOOD CONTROL AGENCY

VOL 4: FRWL IMPROVEMENTS PLANS (PROJECT D)

TYPICAL SECTIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

DRAWING NO. C-301

SHEET 18

A

Subsurface Explorations

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES			GROUP SYMBOL	SOIL GROUP NAMES & LEGEND
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO 4. SIEVE	CLEAN GRAVELS <5% FINES	$C_u \geq 4$ AND $1 \leq C_c \leq 3$	GW	WELL-GRADED GRAVEL
			$C_u < 4$ AND/OR $1 > C_c > 3$	GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR MH	GM	SILTY GRAVEL
			FINES CLASSIFY AS CL OR CH	GC	CLAYEY GRAVEL
	SANDS >50% OF COARSE FRACTION PASSES NO 4. SIEVE	CLEAN SANDS <5% FINES	$C_u \geq 6$ AND $1 \leq C_c \leq 3$	SW	WELL-GRADED SAND
			$C_u < 6$ AND/OR $1 > C_c > 3$	SP	POORLY-GRADED SAND
		SANDS AND FINES >12% FINES	FINES CLASSIFY AS ML OR MH	SM	SILTY SAND
			FINES CLASSIFY AS CL OR CH	SC	CLAYEY SAND
FINE-GRAINED SOILS >50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT<50	INORGANIC	PI>7 AND PLOTS>"A" LINE	CL	LEAN CLAY
			PI<4 OR PLOTS<"A" LINE	ML	SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OL	ORGANIC CLAY OR SILT
	SILTS AND CLAYS LIQUID LIMIT>50	INORGANIC	PI PLOTS >"A" LINE	CH	FAT CLAY
			PI PLOTS <"A" LINE	MH	ELASTIC SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OH	ORGANIC CLAY OR SILT
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	PEAT

OTHER SYMBOLS

MATERIALS	SAMPLERS
Asphalt	SPT (2" OD)
Aggregate Base	Modified California (3" OD)
Boulders & Cobbles	California (2.5" OD)
Fill	Shelby Tube
Topsoil	Pitcher Barrel
	HQ Core
	Grab/Bulk

PIEZOMETER

- Concrete Grout/Fill
- Bentonite/Grout Seal
- Sand Pack + Solid Pipe
- Sand Pack + Slotted Pipe

INITIAL WATER LEVEL MEASUREMENT(WITH DATE)

STABILIZED WATER LEVEL MEASUREMENT(WITH DATE)

GRAIN SIZES

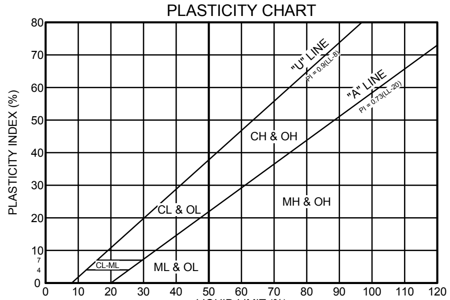
U.S. STANDARD SIEVE	200	40	10	4	3/4"	3"	12"
SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

PENETRATION RESISTANCE

SAND & GRAVEL		SILT & CLAY		
RELATIVE DENSITY	BLOWS/FOOT*	CONSISTENCY	BLOWS/FOOT*	UNC. COMP. STRENGTH (KSF)
VERY LOOSE	0 - 4	VERY SOFT	0 - 1	0 - 1/2
LOOSE	5 - 10	SOFT	2 - 4	1/2 - 1
MEDIUM DENSE	11 - 30	FIRM	5 - 8	1 - 2
DENSE	31 - 50	STIFF	9 - 15	2 - 4
VERY DENSE	OVER 50	VERY STIFF	16 - 30	4 - 8
		HARD	OVER 30	OVER 8

* NUMBER OF BLOWS OF 140 LB HAMMER FALLING 30 INCHES TO DRIVE A 2 INCH O.D. (1-3/8 INCH I.D.) SPLIT-BARREL SAMPLER THE LAST 12 INCHES OF AN 18-INCH DRIVE (ASTM-1586 STANDARD PENETRATION TEST).

PLASTICITY CHART



NOTES

AT	ATTERBERG LIMITS
BGS	BELOW GROUND SURFACE
c	COHESION
CD	CONSOLIDATED DRAINED TRIAXIAL
CN	CONSOLIDATION
CR	CORROSIVITY
CU	CONSOLIDATED UNDRAINED TRIAXIAL
DS	DIRECT SHEAR
EI	EXPANSION INDEX
HY	HYDROMETER
LL	LIQUID LIMIT
N_f	FIELD BLOW COUNT
PI	PLASTICITY INDEX
PR	PERMEABILITY
RV	R-VALUE
SA	SIEVE ANALYSIS
-200	% PASSING NO. 200 SIEVE
TC	CYCLIC TRIAXIAL
UC	UNCONFINED COMPRESSION
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL

INCREASING VISUAL MOISTURE CONTENT

- WET
- MOIST
- DRY

HDR

Boring Legend

Oroville Wildlife Area
Oroville, California

Date

Figure
A-1

TEST 240578_OROVILLE WILDLIFE AREA_BORINGS WITH LAB_20160115.GPJ TEST_SEPT_2014_HDR.GPJ 1/28/16

Project: Oroville Wildlife Area	Boring ID: B-01	Sheet 1 of 2 Sheets
Project Location: Oroville, California		
Project Number: 028-240578		

Start Date: 8/18/2015	End Date: 8/18/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): Taber Drilling (Truck CME75)		Inspector: Butte County (Call)	Weather Conditions: Clear, hot	
Drill Method: HSA (3.25" I.D. / 7.25" O.D.)		Drilled By: Daniel Snell	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 51.5 ft.	Elevation Top of Boring: 135.8	
Hammer Type: Automatic		Hole Backfill: Cement grout / bentonite chips	Latitude: 39.455889	Longitude: -121.61735
Hammer Efficiency: 76%	Rod Type:	Total Number of Samples: 11 Disturbed: 11 Undisturbed: 0	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	Blows/6" or Press.	N_f	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
135		18 16 12	28	COBBLES, GRAVEL, SAND, and SILT: gray-brown, medium dense, dry, fine to coarse gravel and cobbles, fine- to coarse-grained sand, low plasticity fines	39	S1								Drill pilot hole to 1' with 6" SFA then switch to 7.25" HSA.
				[See NOTE at end of log regarding material description]										Significant drill chatter observed from the ground surface down to about 22' depth.
130	5	13 9 3	12	- loose	0									
		7 4 3	7		0									
125	10	14 5 2	7		17	S2								
120	15	8 3 1	4	- very loose	8	S3								
115	20	7 20 50/3"	50/3"	- dense	0									
		16 11 8	19	Well-graded SAND with Silt (SW-SM): dark gray-brown, medium dense, moist, fine- to coarse-grained sand, trace fine gravel, low plasticity fines	33	S4	6	87	7					Drill string drifted about 1' to the east by 23' feet depth. Drill rig was repositioned before continuing drilling. The driller reported smoother drilling below 23.5'.
110	25	6 7 7	14		11	S5								
				Poorly-graded SAND with Silt and Gravel (SP-SM): dark gray-brown, medium dense, moist, fine- to coarse-grained sand, fine subangular to rounded gravel, low plasticity fines										

Project:	Oroville Wildlife Area	Boring ID:	Sheet
Project Location:	Oroville, California	B-01	2 of 2 Sheets
Project Number:	028-240578		

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
105			5 6 6	12			50	S6	19	76	6					Driller began adding water to the auger to prevent sand blow-out.
						Poorly-graded SAND with Silt (SP-SM): dark gray-brown, loose to medium dense, moist, fine- to coarse-grained sand, trace fine subangular to rounded gravel, low plasticity fines										
100	35		2 5 5	10			39	S7								Sand catcher used for SPT samples from 30' to 41.5'.
						Sandy SILT (ML): very dark brown, moist, hard, non-plastic, rapid dilatancy, fine- to coarse-grained sand, cemented rock-like structure with distinct bedding										
95	40		12 28 48	76			100	S8	0	35	65	43	NP		49	
90	45		17 33 41	74			89	S9 S10								
						Silty SAND (SM): very dark brown, very dense, moist, fine-grained sand, low plasticity fines, trace cemented sand fragments										
85	50		16 45 50/5"	50/5"		- increased cementation (mostly moderately cemented silty sand)	100	S11								

Bottom of boring at 51.5 feet depth

NOTE: Material from the ground surface to a depth of about 22' likely contains significant quantities of gravel and cobbles that could not readily be sampled with the equipment available at the time of drilling. Therefore, material descriptions over the aforementioned thickness are inferred based on observations of: 1) drill rig behavior, 2) material collected in drive samplers, 3) material encountered in Test Pit TP-03, 4) gravel and cobbles exposed at the ground surface and on levee slopes, 5) and other relevant observations during drilling.

HDR	Project: Oroville Wildlife Area		Boring ID:	Sheet 1 of 2 Sheets
	Project Location: Oroville, California		B-02	
	Project Number: 028-240578			

Start Date: 8/19/2015	End Date: 8/19/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): Taber Drilling (Truck CME75)		Inspector: Butte County (Call)	Weather Conditions: Clear, hot	
Drill Method: HSA (3.25" I.D. / 7.25" O.D.)		Drilled By: Daniel Snell	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 36.5 ft.	Elevation Top of Boring: 135.7	
Hammer Type: Automatic		Hole Backfill: Cement grout / bentonite chips	Latitude: 39.455923	Longitude: -121.615816
Hammer Efficiency: 76%	Rod Type:	Total Number of Samples: 12 Disturbed: 12 Undisturbed: 0	Depth of Ground Water: Initial: 26.8 (;)	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
135			24 30/4"	30/4"		COBBLES, GRAVEL, SAND, and SILT: gray-brown, dense, dry, fine to coarse gravel and cobbles, fine- to coarse-grained sand, low plasticity fines [See NOTE at end of log regarding material description]	70	S1								Drill pilot hole to 1' with 6" SFA then switch to 7.25" HSA. Significant drill chatter observed from the ground surface down to about 29' depth.
130	5		14 20 17	37		- dark gray-brown, medium dense, moist	44	S2 S3								
			48 12 7	19			44	S4								
125	10		14 14 9	23			22	S5								
120	15		22 23 23	46		COBBLES, GRAVEL, SAND, and CLAY: dark brown, dense, moist, fine to coarse gravel and cobbles, fine- to coarse-grained sand, medium plasticity fines [See NOTE at end of log regarding material description]	33	S6								Auger cutting teeth wore out at 18'. Removed auger to replace bit before drilling to 20'.
115	20		16 11 12	23		- medium dense	31	S7								
110	25		5 5 5	10		- wet, loose to medium dense, rounded coarse gravel	0									
▽			16 12 6	18			0	S8								No recovery with SPT; re-drove 26.5' to 28' interval with MC and sand catcher to recover sample S8.
						Well-graded SAND with Silt (SW-SM): dark gray-brown, very loose, wet, fine- to										

Project: Oroville Wildlife Area	Boring ID:	Sheet
Project Location: Oroville, California	B-02	2 of 2 Sheets
Project Number: 028-240578		

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
105			1 0 0	0		coarse-grained sand, trace fine gravel, low plasticity fines	56	S9								Sand catcher used for SPT samples from 30' to 36.5'.
			12 15 9	24		Poorly-graded SAND with Silt (SP-SM): dark gray-brown, medium dense, moist, fine- to medium-grained sand, low plasticity fines	100	S10	0	81	19					Driller began adding water to the auger to prevent sand blow-out.
	35					- medium- to coarse-grained sand		S11								
100			30 8 13	21		Silty SAND with Gravel (SM): dark gray-brown, medium dense, moist, fine- to coarse-grained sand, fine to coarse subrounded to angular gravel, low plasticity fines	83	S12								

Bottom of boring at 36.5 feet depth

NOTE: Material from the ground surface to a depth of about 29' likely contains significant quantities of gravel and cobbles that could not readily be sampled with the equipment available at the time of drilling. Therefore, material descriptions over the aforementioned thickness are inferred based on observations of: 1) drill rig behavior, 2) material collected in drive samplers, 3) material encountered in Test Pit TP-04, 4) gravel and cobbles exposed at the ground surface and on levee slopes, 5) and other relevant observations during drilling.

REMARKS: The boring could not be advanced deeper than 36.5' due to sand within the auger drill string causing the center bit to get stuck within the augers.

HDR	Project: Oroville Wildlife Area Project Location: Oroville, California Project Number: 028-240578	Boring ID: **B-03**	Sheet 1 of 2 Sheets
Start Date: 8/18/2015	End Date: 8/18/2015	Logged By: V. Crosariol	Checked By: EPW
Date Checked: 1/15/2016	Drilling Company (Rig Type): Taber Drilling (Truck CME75)	Inspector: Butte County (Call)	Weather Conditions: Clear, hot
Drill Method: HSA (3.25" I.D. / 7.25" O.D.)	Drilled By: Daniel Snell	Coordinate System: Vertical Datum: NAVD88 Horizontal Datum: NAD83	
Drill Bit (Type/Size): /	Total Depth Drilled: 31.5 ft.	Elevation Top of Boring: 117.5	
Hammer Type: Automatic	Hole Backfill: Cement grout / bentonite chips	Latitude: 39.455599	Longitude: -121.616557
Hammer Efficiency: 76%	Rod Type:	Total Number of Samples: 8 Disturbed: 8 Undisturbed: 0	Depth of Ground Water: Initial: 8.4 (;) Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
115			10 12 16	28		COBBLES, GRAVEL, SAND, and SILT: gray-brown, medium dense, dry, fine to coarse gravel and cobbles, fine- to coarse-grained sand, trace low plasticity fines [See NOTE at end of log regarding material description]	44	S1								Drill pilot hole to 0.5' with 6" SFA then switch to 7.25" HSA. Drill chatter observed from the ground surface down to about 4.5' depth. Decrease in drill chatter below 4.5'
	5		16 16 14	30			0									
110	▽		2 2 2	4		Poorly-graded SAND (SW): dark gray-brown, very loose, moist, fine- to coarse-grained sand, trace fine gravel, trace low plasticity fines	0	S2								No recovery with SPT; re-drove 5.0' to 6.5' interval with SPT and sand catcher to recover sample S2.
	10		1 3 3	6		- loose	100	S3	2	96	1					Driller began adding water to the auger to prevent sand blow-out.
105																Sand catcher used for SPT samples from 10' to 25.5'.
	15		3 3 4	7			44	S4								
100						SILT with Sand (ML): very dark brown, moist, soft, low plasticity, rapid dilatancy, primarily fine-grained sand										
	20		2 2 6	8			78	S5	0	23	77	35	5		41	
						Silty SAND (SM): dark brown, loose to medium dense, moist, fine- to coarse-grained sand, low plasticity fines		S6								
95																
	25		12 13 22	35		- dark brown, dense, fine- to coarse-grained sand, trace fine gravel, low plasticity fines, with cemented sand fragments	100	S7	0	70	30					
90																

Project: Oroville Wildlife Area	Boring ID:	Sheet
Project Location: Oroville, California	B-03	2 of 2 Sheets
Project Number: 028-240578		

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
			12 16 22	38		- no apparent cementation	67	S8								

Bottom of boring at 31.5 feet depth

NOTE: Material from the ground surface to a depth of about 7' likely contains significant quantities of gravel and cobbles that could not readily be sampled with the equipment available at the time of drilling. Therefore, material descriptions over the aforementioned thickness are inferred based on observations of: 1) drill rig behavior, 2) material collected in drive samplers, 3) material encountered in Test Pits TP-03 and TP-04, 4) gravel and cobbles exposed at the ground surface, 5) and other relevant observations during drilling.

HDR	Project: Oroville Wildlife Area Project Location: Oroville, California Project Number: 028-240578	Boring ID: B-04	Sheet 1 of 2 Sheets

Start Date: 8/20/2015	End Date: 8/20/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): Taber Drilling (Truck CME75)		Inspector: Butte County (Call)	Weather Conditions: Clear, hot	
Drill Method: HSA (3.25" I.D. / 7.25" O.D.)		Drilled By: Daniel Snell	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 50.4 ft.	Elevation Top of Boring: 119.5	
Hammer Type: Automatic		Hole Backfill: Cement grout / bentonite chips	Latitude: 39.430798	Longitude: -121.626819
Hammer Efficiency: 76%	Rod Type:	Total Number of Samples: 12 Disturbed: 12 Undisturbed: 0	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						COBBLES, GRAVEL, SAND, and SILT: dark gray-brown, medium dense, dry, fine to coarse gravel and cobbles, fine- to coarse-grained sand, low plasticity fines										Drill pilot hole to 1' with 6" SFA then switch to 7.25" HSA.
			16 15 14	29			39	S1								Drill chatter observed from the ground surface down to about 19' depth.
						[See NOTE at end of log regarding material description]										
115	5		6 3 2	5		- loose	8	S2								Rounded and fractured gravel in SPT shoe.
			1 2 3	5			0									Outer surface of sampler dry upon retrieval.
110	10		2 5 3	8		COBBLES, GRAVEL, SAND, and CLAY: dark brown, loose, moist, fine to coarse gravel and cobbles, fine- to coarse-grained sand, medium plasticity fines	22	S3								Outer surface of sampler moist upon retrieval. Driller added water around auger to east drilling.
						[See NOTE at end of log regarding material description]										
105	15		5 5 3	8		- wet	11	S4								
			2 2 3	5		- trace black organics, slight organic odor	17	S5								
100	20		3 3 3	6		Poorly-graded SAND (SP): dark gray-brown, loose, moist, fine- to coarse-grained sand, trace fine gravel, trace low plasticity fines	61	S6	6	91	3					
95	25		2 3 4	7		- primarily fine- to medium-grained sand	44	S7								Driller began adding water to the auger to prevent sand blow-out. Sand catcher used for SPT samples from 25' to 36.5'.
90						Well-graded SAND (SW): dark gray-brown, loose, moist, fine- to coarse-grained sand, trace fine gravel, trace low plasticity fines										

Project: Oroville Wildlife Area	Boring ID:	Sheet
Project Location: Oroville, California	B-04	2 of 2 Sheets
Project Number: 028-240578		

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
			2 3 5	8			39	S8								
85	35		4 3 4	7		SILT with Sand (ML): dark gray-brown, medium stiff, moist, non-plastic, rapid dilatancy, fine- to medium-grained sand - 2" lense of silty sand at 36'	61	S9	1	18	81	31	NP		40	
80	40		9 27 50/4"	50/4"		Well-graded GRAVEL with Clay and Sand (GW-GC): olive-gray, dense to very dense, moist, fine to coarse subangular to subrounded gravel, fine- to coarse-grained sand, medium plasticity fines	50	S10	61	31	8					Hard drilling below 38 feet.
75	45		50/2.5"	50/2.5"		Clayey SAND (SC): olive-gray, very dense, moist, fine- to coarse-grained sand, trace fine gravel, medium plasticity fines	98	S11								
70	50		50/5"	50/5"		Poorly-graded GRAVEL with Clay and Sand (GP-GC): very dark gray, very dense, moist, fine to coarse gravel, fine- to coarse-grained sand, olive-gray medium plasticity fines, oxidation staining	100	S12								Gravel appeared shaley and was generally cut to SPT sampler diameter.

Bottom of boring at 50.4 feet depth

NOTE: Material from the ground surface to a depth of about 19' likely contains significant quantities of gravel and cobbles that could not readily be sampled with the equipment available at the time of drilling. Therefore, material descriptions over the aforementioned thickness are inferred based on observations of: 1) drill rig behavior, 2) material collected in drive samplers, 3) material encountered in Test Pit TP-06, 4) gravel and cobbles exposed at the ground surface and on levee slopes, 5) and other relevant observations during drilling.

Project: Oroville Wildlife Area	Boring ID:	Sheet 1 of 2 Sheets
Project Location: Oroville, California	B-05	
Project Number: 028-240578		

Start Date: 8/20/2015	End Date: 8/20/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): Taber Drilling (Truck CME75)		Inspector: Butte County (Call)	Weather Conditions: Clear, hot	
Drill Method: HSA (3.25" I.D. / 7.25" O.D.)		Drilled By: Daniel Snell	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 51.8 ft.	Elevation Top of Boring: 123.6	
Hammer Type: Automatic		Hole Backfill: Cement grout / bentonite chips	Latitude: 39.430155	Longitude: -121.624203
Hammer Efficiency: 76%	Rod Type:	Total Number of Samples: 14 Disturbed: 14 Undisturbed: 0	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
			13 19 14	33		COBBLES, GRAVEL, SAND, and SILT: dark gray-brown, medium dense, dry, fine to coarse gravel and cobbles, fine- to coarse-grained sand, low plasticity fines	33	S1								Drill pilot hole to 1' with 6" SFA then switch to 7.25" HSA.
120						[See NOTE at end of log regarding material description]										Drill chatter observed from the ground surface down to about 27' depth. Very hard drilling; driller added water around auger to east drilling.
	5		13 16 15	31			0									
115			23 13 12	25			36	S2								
	10		30 16 33	49		- moist	19	S3								
110						COBBLES, GRAVEL, SAND, and CLAY: red-brown, loose, moist, fine to coarse gravel and cobbles, fine- to coarse-grained sand, medium plasticity fines										
	15		24 14 14	28		[See NOTE at end of log regarding material description]	44	S4								
105																Driller began adding water to the auger to prevent sand blow-out.
	20		26 28 30	58		- decrease in clay content	50	S5								
100																
	25		8 14 14	28			0									
95			7 11 11	22		Silty SAND (SM): dark gray-brown to dark gray, medium dense, moist, fine- to coarse-grained sand, low plasticity fines, trace silt seams	31	S6								Easier drilling below 27'. Sand catcher used for SPT samples from 27.5 to 31.5'.

HDR

Project: Oroville Wildlife Area

Project Location: Oroville, California

Project Number: 028-240578

Boring ID: B-05

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
			4 5 3	8		- dark gray-brown, loose	50	S7	0	85	16					
90						Poorly-graded SAND with Silt (SP-SM): dark gray-brown, loose, moist, fine- to medium-grained sand, low plasticity fines										
	35		2 4 5	9		- 1.5" lense of fine-grained sand	100	S8								
85																Harder drilling below 38 feet.
	40		4 14 8	22		- medium dense	100	S9	0	90	10					
80	45					SILT (ML): dark gray-brown, low plasticity, rapid dilatancy, trace fine-grained sand	100	S10*								Sand blew into auger upon removal of the center bit at 45'; MC sampler was used to clean sand from within the auger; the center bit was replaced before drilling to 48'. *Sample S10 was collected from the auger center bit.
						Poorly-graded SAND with Silt (SP-SM): dark brown, medium dense, moist, fine- to medium-grained sand, low plasticity fines		S11								
75			3 15 26	41		SILT with Gravel (ML): olive-gray with yellow brown bands, very stiff to hard, moist, low to medium plasticity, fine gravel, trace sand	100	S12	11	5	84	49	14		29	
	50		12 46 50/4"	50/4"		Silty SAND with Gravel (SM): very dense, fine- to coarse-grained sand, moist, olive-gray, fine angular gravel, low to medium plasticity fines	100	S13 S14								

Bottom of boring at 50.4 feet depth

NOTE: Material from the ground surface to a depth of about 27' likely contains significant quantities of gravel and cobbles that could not readily be sampled with the equipment available at the time of drilling. Therefore, material descriptions over the aforementioned thickness are inferred based on observations of: 1) drill rig behavior, 2) material collected in drive samplers, 3) material encountered in Test Pit TP-07, 4) gravel and cobbles exposed at the ground surface and on levee slopes, 5) and other relevant observations during drilling.

HDR	Project: Oroville Wildlife Area Project Location: Oroville, California Project Number: 028-240578	Boring ID: TP-01	Sheet 1 of 1 Sheets
Start Date: 8/12/2015	End Date: 8/12/2015	Logged By: V. Crosariol	Checked By: EPW
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)	Inspector: None	Weather Conditions: Clear, hot	Date Checked: 1/15/2016
Drill Method: 24" backhoe bucket	Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88 Horizontal Datum: NAD83	
Drill Bit (Type/Size): /	Total Depth Drilled: 2.5 ft.	Elevation Top of Boring: 132.5	
Hammer Type:	Hole Backfill: Rock and Soil	Latitude: 39.453975	Longitude: -121.635459
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial: Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
132						COBBLES and GRAVEL (GW): gray rock, dry, subrounded to rounded coarse gravel and cobbles (up to 12 inches), little sand or fines										Start digging at 13:00 hrs Hard digging through entire test pit
131	1					COBBLES and GRAVEL with Silt and Sand (GW-GM): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 12 inches), fine- to coarse-grained sand, silt fines										
130	2					- increased moist sand and silt content in bucket scoop from below 2.5'										Very unstable side walls; could not dig deeper than 2.5 feet
						Bottom of test pit at 2.5 feet depth										Finish test pit backfill at 13:45 hrs

HDR	Project: Oroville Wildlife Area Project Location: Oroville, California Project Number: 028-240578		Boring ID: TP-02	Sheet 1 of 1 Sheets
Start Date: 8/12/2015	End Date: 8/12/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 2.8 ft.	Elevation Top of Boring: 134.0	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.453421	Longitude: -121.635558
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						COBBLES and GRAVEL with Silt and Sand (GW-GM): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 13 inches), fine- to coarse-grained sand, silt fines, trace rootlets										Start digging at 12:15 hrs Hard digging through entire test pit
133	1															
132	2					- no rootlets below 0.8 feet										Very unstable side walls; could not dig deeper than 2.8 feet
						Bottom of test pit at 2.8 feet depth										Finish test pit backfill at 12:40 hrs

Project: Oroville Wildlife Area	Boring ID:	Sheet 1 of 1 Sheets
Project Location: Oroville, California	TP-03	
Project Number: 028-240578		

Start Date: 8/12/2015	End Date: 8/12/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 3.3 ft.	Elevation Top of Boring: 136.0	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.455900	Longitude: -121.617263
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						COBBLES and GRAVEL with Silt and Sand (GW-GM): gray rock, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 13 inches), fine- to coarse-grained sand, brown silt fines, trace dry brush at surface										Start digging at 09:00 hrs
																Hard digging through entire test pit
135	1															Material began to cave below 1 foot
134	2															
133	3															Very unstable side walls; terminated test pit at 3.3 feet
						Bottom of test pit at 3.3 feet depth										Finish test pit backfill at 09:30 hrs

HDR	Project: Oroville Wildlife Area Project Location: Oroville, California Project Number: 028-240578	Boring ID: TP-04	Sheet 1 of 1 Sheets

Start Date: 8/12/2015	End Date: 8/12/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88 Horizontal Datum: NAD83	
Drill Bit (Type/Size): /		Total Depth Drilled: 2.8 ft.	Elevation Top of Boring: 136.0	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.455891	Longitude: -121.615974
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial: Static:	

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						COBBLES and GRAVEL with Silt and Sand (GW-GM): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 16 inches), fine- to coarse-grained sand, silt fines, trace dry brush at surface										Start digging at 09:50 hrs Hard digging through entire test pit
135	1															
134	2					COBBLES and GRAVEL with Clay and Sand (GW-GM): gray rock and brown soil, moist, subrounded to rounded fine to coarse gravel and cobbles (up to 16 inches), fine- to coarse-grained sand, clay fines										Very unstable side walls; terminated test pit at 2.8 feet
						Bottom of test pit at 2.8 feet depth										Finish test pit backfill at 10:35 hrs

HDR	Project: Oroville Wildlife Area Project Location: Oroville, California Project Number: 028-240578	Boring ID: TP-05	Sheet 1 of 1 Sheets

Start Date: 8/12/2015	End Date: 8/12/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 3.7 ft.	Elevation Top of Boring: 115.0	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.456027	Longitude: -121.613127
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial: 3.3 (8/12/2015;)	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						COBBLES and GRAVEL Sand (GW): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 12 inches), fine- to coarse-grained sand, trace fines										Start digging at 11:00 hrs
																Hard digging down to 2 feet
114	1															
						- moist, increased fine- to coarse-grained sand content (very dark gray)										Unstable side walls
113	2					Poorly-graded SAND with Gravel (SP): brown, moist, medium- to coarse-grained sand, fine to coarse subrounded to rounded gravel, trace rootlets and roots up to 3/4 inch										
112	3															
∇						- wet at 3.3 feet										Water seeping into test pit at 3.3 feet (approximate river level) Finish test pit backfill at 11:45 hrs

Bottom of test pit at 3.7 feet depth

Project: Oroville Wildlife Area	Boring ID:	Sheet 1 of 1 Sheets
Project Location: Oroville, California	TP-06	
Project Number: 028-240578		

Start Date: 8/12/2015	End Date: 8/12/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 3.5 ft.	Elevation Top of Boring: 108.0	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.430718	Longitude: -121.626565
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						COBBLES and GRAVEL with Silt and Sand (GW-GM): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 12 inches), fine- to coarse-grained sand, silt fines, dry brush at surface										Start digging at 15:40 hrs Hard digging through entire test pit
107	1															
106	2					- increase in cobble content below 2 feet										Harder digging below 2 feet
105	3															
						Bottom of test pit at 3.5 feet depth										Finish test pit backfill at 16:25 hrs

HDR	Project: Oroville Wildlife Area Project Location: Oroville, California Project Number: 028-240578	Boring ID: TP-07	Sheet 1 of 1 Sheets

Start Date: 8/12/2015	End Date: 8/12/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 2.8 ft.	Elevation Top of Boring: 123.5	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.429964	Longitude: -121.623978
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
123						COBBLES and GRAVEL with Sand (GW): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 12 inches), fine- to coarse-grained sand, trace silt fines, dry brush at surface										Start digging at 16:50 hrs Hard digging through entire test pit
	1															
122																
	2															
121																Very unstable side walls; terminated test pit at 2.8 feet
						Bottom of test pit at 2.8 feet depth										Finish test pit backfill at 17:20 hrs

Project: Oroville Wildlife Area		Boring ID:	Sheet 1 of 1 Sheets
Project Location: Oroville, California		TP-08	
Project Number: 028-240578			

Start Date: 8/13/2015	End Date: 8/13/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 3.9 ft.	Elevation Top of Boring: 104.0	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.423678	Longitude: -121.623019
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						GRAVEL with Silt and Sand (GW-GM): brow, dry, fine to coarse gravel, silt fines, rootlets, dry brush at surface										Start digging at 08:30 hrs
						COBBLES and GRAVEL with Sand (GW): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 12 inches), fine- to coarse-grained sand, trace silt fines, dry brush at surface										Hard digging through entire test pit
103	1															Significantly higher cobble content observed on the east side of test pit, which appears to be cut into the cobble pile next to the road.
102	2					- increase in cobble content below 2 feet										
101	3															
						Bottom of test pit at 3.9 feet depth										Finish test pit backfill at 09:25 hrs

Project: Oroville Wildlife Area		Boring ID:	Sheet 1 of 1 Sheets
Project Location: Oroville, California		TP-09	
Project Number: 028-240578			

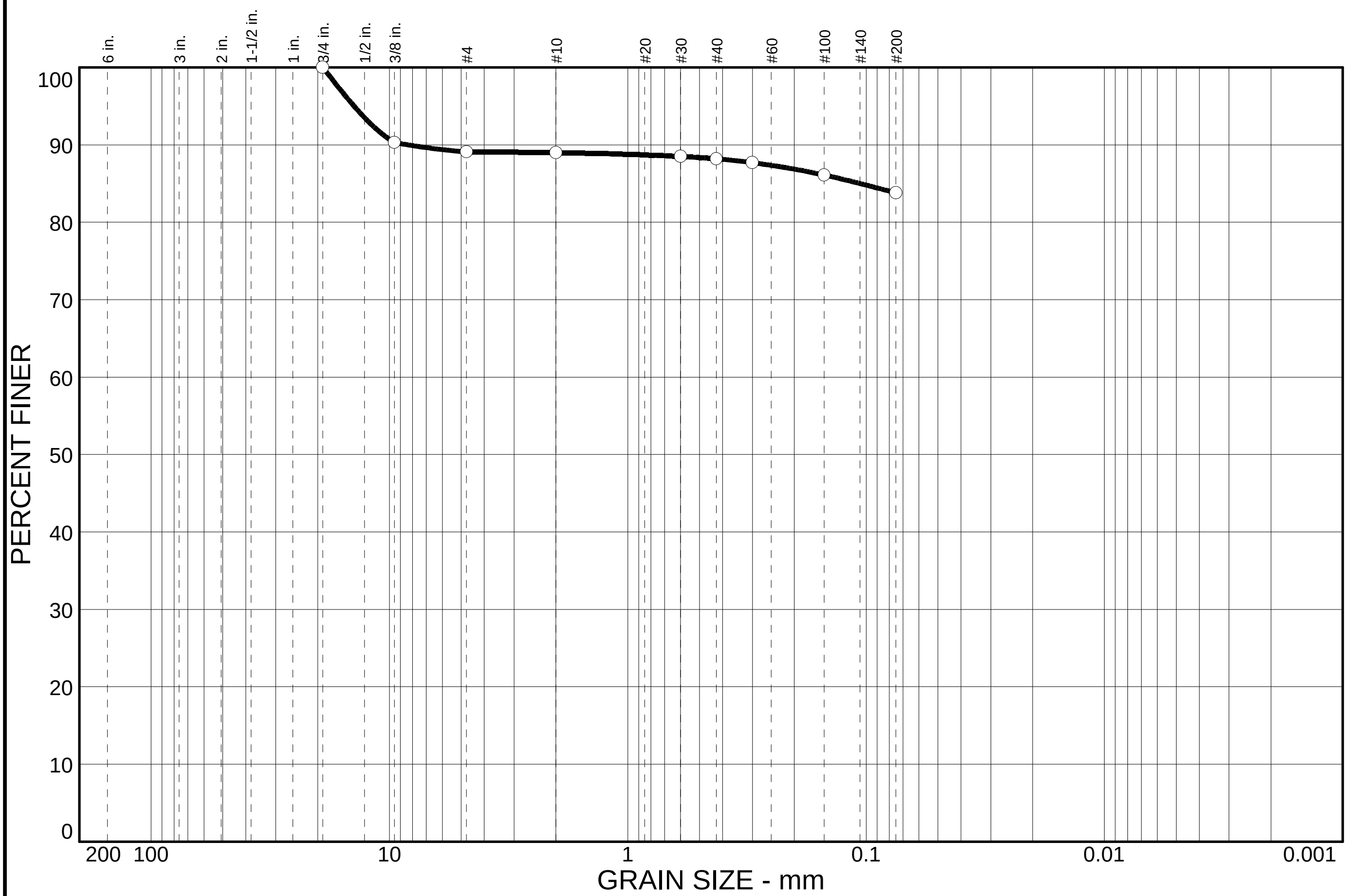
Start Date: 8/13/2015	End Date: 8/13/2015	Logged By: V. Crosariol	Checked By: EPW	Date Checked: 1/15/2016
Drilling Company (Rig Type): HDR (Deere 310J Backhoe)		Inspector: None	Weather Conditions: Clear, hot	
Drill Method: 24" backhoe bucket		Drilled By: Paul Marsden	Coordinate System: Vertical Datum: NAVD88	Horizontal Datum: NAD83
Drill Bit (Type/Size): /		Total Depth Drilled: 2.8 ft.	Elevation Top of Boring: 118.0	
Hammer Type:		Hole Backfill: Rock and Soil	Latitude: 39.422814	Longitude: -121.622927
Hammer Efficiency: %	Rod Type:	Total Number of Samples: Disturbed: Undisturbed:	Depth of Ground Water: Initial:	Static:

ELEV	DEPTH	SAMPLE	Blows/6" or Press.	N_f	LEGEND	DESCRIPTION OF MATERIALS	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	DD	MC	REMARKS
						COBBLES and GRAVEL with Silt and Sand (GW-GM): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 12 inches), fine- to coarse-grained sand, silt fines, trace rootlets										Start digging at 07:20 hrs
						COBBLES and GRAVEL with Sand (GW): gray rock and brown soil, dry, subrounded to rounded fine to coarse gravel and cobbles (up to 12 inches), fine- to coarse-grained sand, trace silt fines, dry brush at surface										Hard digging through entire test pit
117	1															
116	2															
																Very unstable side walls; terminated test pit at 2.8 feet
						Bottom of test pit at 2.8 feet depth										Finish test pit backfill at 08:20 hrs

B

Laboratory Test Results

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		10.9	5.3	83.8		ML		35	49

SIEVE inches size	PERCENT FINER ○		
3/4"	100.0		
3/8"	90.3		

	GRAIN SIZE		
D_{60}			
D_{30}			
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	89.1		
#10	89.0		
#30	88.5		
#40	88.2		
#50	87.7		
#100	86.1		
#200	83.8		

SOIL DESCRIPTION

○ Olive SILT w/ Gravel

REMARKS:

○ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

○ Source: B-05 Sample No.: S12 Elev./Depth: 49-49.5'

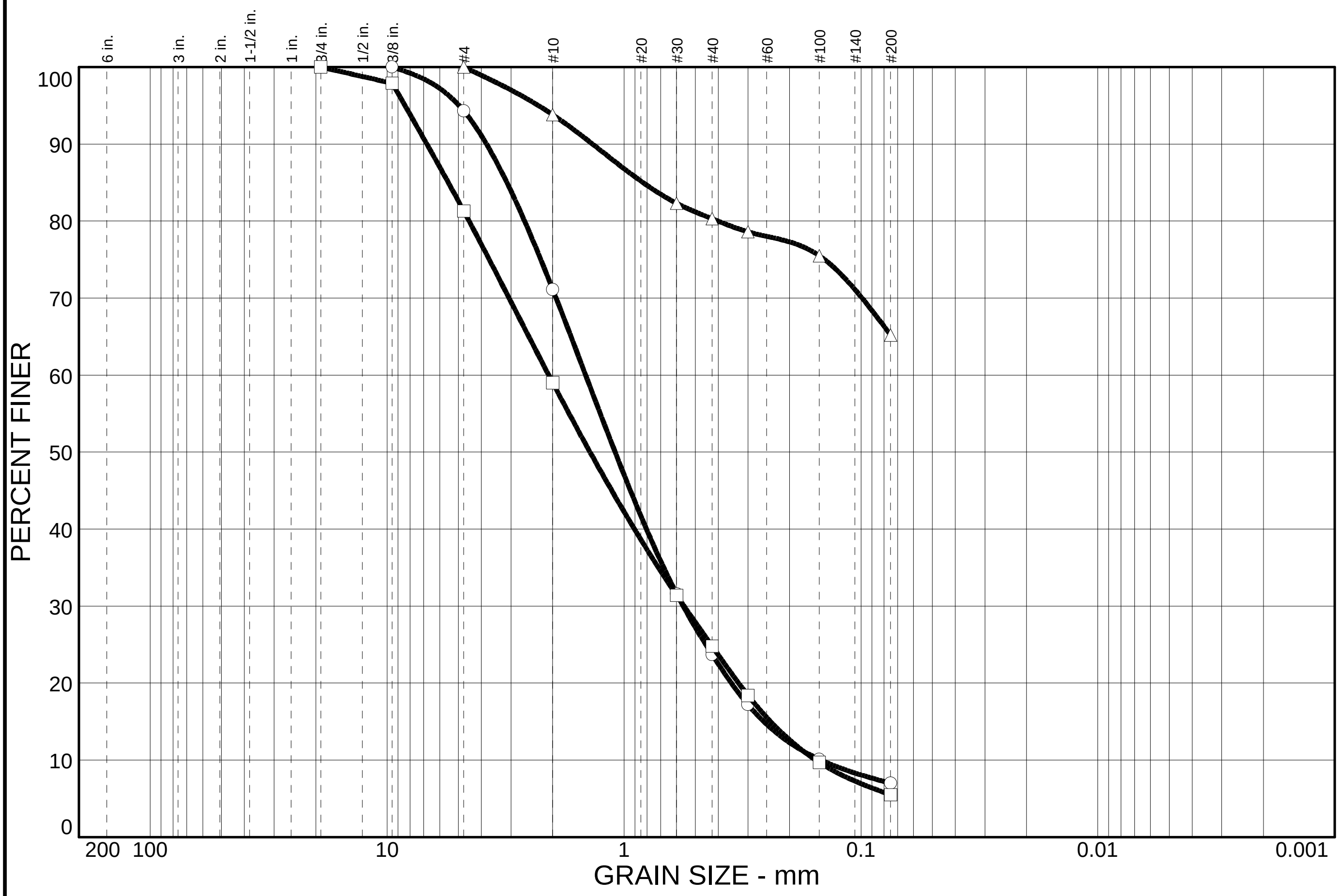
COOPER TESTING LABORATORY

Client: HDR

Project: Oroville Wildlife Area - 028-240578

Project No.: 855-011 Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		5.7	87.3	7.0					
□		18.7	75.8	5.5					
△			34.8	65.2		ML		49	43

SIEVE inches size	PERCENT FINER ○	□	△
3/4"		100.0	
3/8"	100.0	97.9	
	GRAIN SIZE		
D_{60}	1.45	2.08	
D_{30}	0.563	0.559	
D_{10}	0.148	0.155	
	COEFFICIENTS		
C_c	1.48	0.97	
C_u	9.85	13.40	

SIEVE number size	PERCENT FINER ○	□	△
#4	94.3	81.3	100.0
#10	71.1	59.0	93.8
#30	31.6	31.4	82.3
#40	23.7	24.8	80.3
#50	17.2	18.4	78.6
#100	10.1	9.7	75.5
#200	7.0	5.5	65.2

SOIL DESCRIPTION

○ Olive Brown Well-Graded SAND w/ Clay

□ Olive Gray Poorly Graded SAND w/ Clay & Gravel

△ Dark Brown Sandy SILT

REMARKS:

○

□ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

△

○ Source: B-01 Sample No.: S4 Elev./Depth: 22.5-24.0'

□ Source: B-01 Sample No.: S6 Elev./Depth: 30-31.5'

△ Source: B-01 Sample No.: S8 Elev./Depth: 40-41.5'

COOPER TESTING LABORATORY

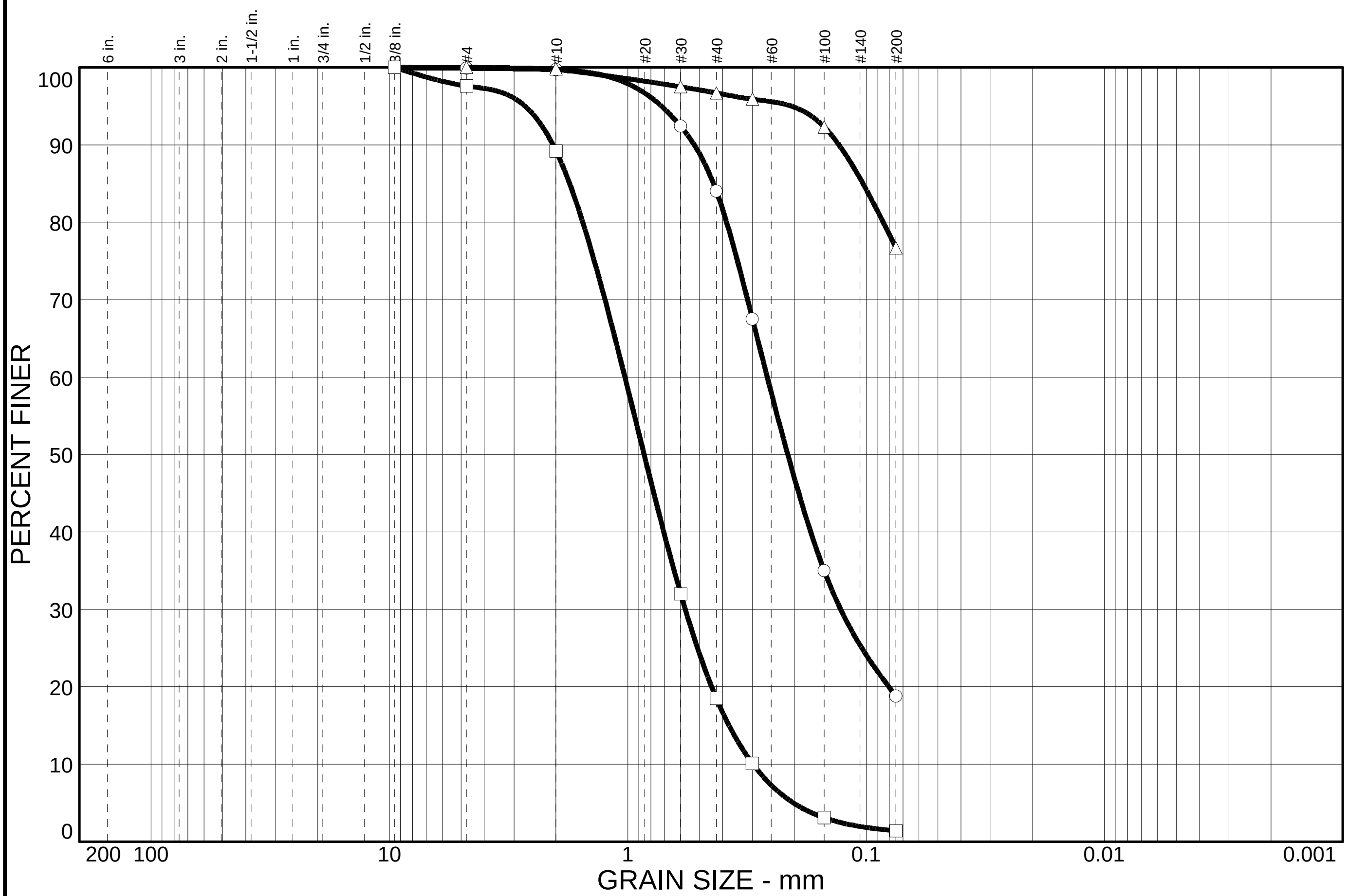
Client: HDR

Project: Oroville Wildlife Area - 028-240578

Project No.: 855-011

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.1	81.1	18.8					
□		2.4	96.2	1.4					
△			23.3	76.7		ML		30	35

SIEVE inches size	PERCENT FINER ○	□	△
3/8"	100.0	100.0	
	GRAIN SIZE		
D_{60}	0.260	1.03	
D_{30}	0.128	0.574	
D_{10}		0.298	
	COEFFICIENTS		
C_c		1.07	
C_u		3.45	

SIEVE number size	PERCENT FINER ○	□	△
#4	99.9	97.6	100.0
#10	99.7	89.2	99.8
#30	92.4	32.0	97.5
#40	84.0	18.5	96.7
#50	67.5	10.1	95.9
#100	35.0	3.1	92.3
#200	18.8	1.4	76.7

SOIL DESCRIPTION

○ Olive Gray Clayey SAND

□ Dark Gray Poorly Graded SAND

△ Grayish Brown SILT w/ Sand

REMARKS:

○

□

△

○ Source: B-02	Sample No.: S10	Elev./Depth: 32.5-34.0'
□ Source: B-03	Sample No.: S3	Elev./Depth: 10-11.5'
△ Source: B-03	Sample No.: S5	Elev./Depth: 20-21'

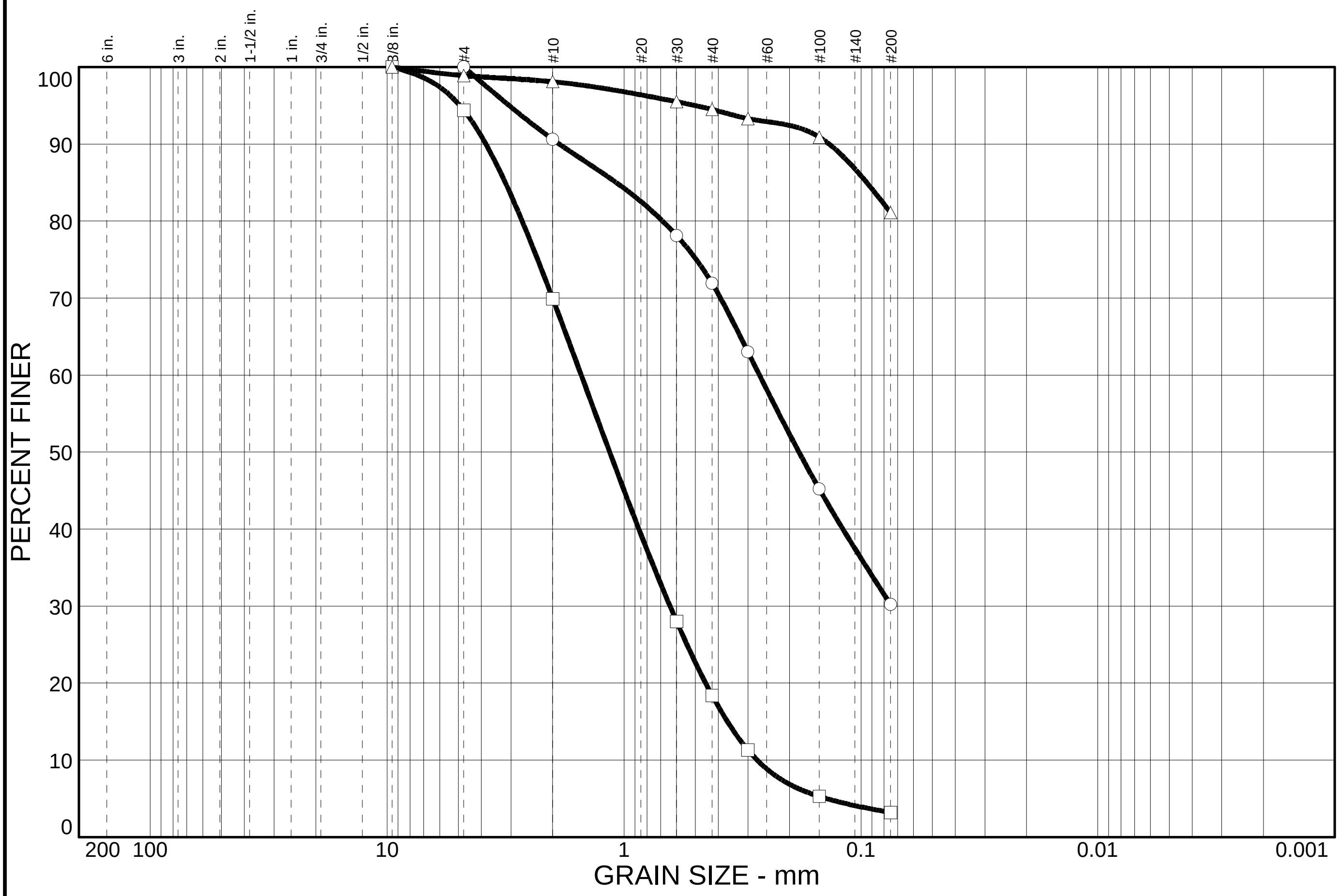
COOPER TESTING LABORATORY

Client: HDR

Project: Oroville Wildlife Area - 028-240578

Project No.: 855-011 Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			69.8	30.2					
□		5.6	91.2	3.2					
△		1.1	17.8	81.1		ML		35	31

SIEVE inches size	PERCENT FINER ○	□	△
3/8"		100.0	100.0
	GRAIN SIZE		
D_{60}	0.268	1.52	
D_{30}		0.640	
D_{10}		0.274	
	COEFFICIENTS		
C_c		0.98	
C_u		5.53	

SIEVE number size	PERCENT FINER ○	□	△
#4	100.0	94.4	98.9
#10	90.6	69.9	98.1
#30	78.1	28.0	95.5
#40	71.9	18.4	94.5
#50	63.0	11.3	93.3
#100	45.2	5.3	90.9
#200	30.2	3.2	81.1

SOIL DESCRIPTION

○ Dark Olive Brown Clayey SAND

□ Olive Brown Poorly Graded SAND

△ Grayish Brown SILT w/ Sand

REMARKS:

○

□

△

○ Source: B-03 Sample No.: S7 Elev./Depth: 25-26.5'

□ Source: B-04 Sample No.: S6 Elev./Depth: 20-21.5'

△ Source: B-04 Sample No.: S9 Elev./Depth: 35-36.5'

COOPER TESTING LABORATORY

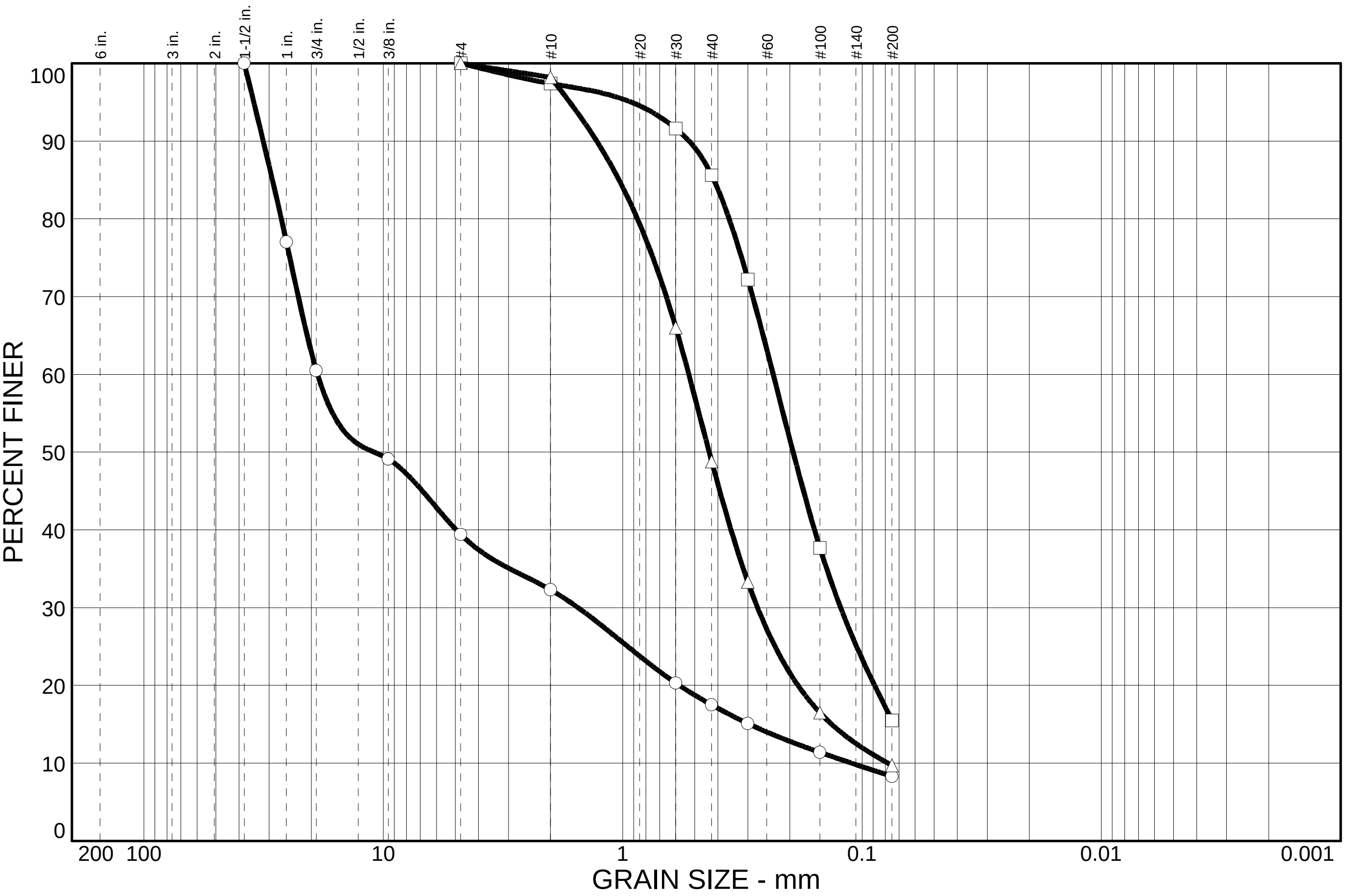
Client: HDR

Project: Oroville Wildlife Area - 028-240578

Project No.: 855-011

Figure

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		60.6	31.1	8.3					
□			84.5	15.5					
△			90.3	9.7					

SIEVE inches size	PERCENT FINER ○	□	△
1.5"	100.0		
1"	77.0		
3/4"	60.5		
3/8"	49.1		
	GRAIN SIZE		
D_{60}	18.8	0.235	0.530
D_{30}	1.54	0.123	0.273
D_{10}	0.110		0.0780
	COEFFICIENTS		
C_c	1.14		1.81
C_u	170.62		6.79

SIEVE number size	PERCENT FINER ○	□	△
#4	39.4	100.0	100.0
#10	32.3	97.4	98.2
#30	20.3	91.6	66.0
#40	17.5	85.6	48.8
#50	15.1	72.2	33.3
#100	11.4	37.7	16.5
#200	8.3	15.5	9.7

SOIL DESCRIPTION

○ Olive Gray Well-Graded GRAVEL GRAVEL w/ Clay & Sand

□ Olive Gray Clayey SAND

△ Olive Gray Well-Graded SAND w/ Clay

REMARKS:

○ Due to the small sample size, relative to the largest particle size, this data should be considered to be approximate.

□

△

Source	Sample No.	Elev./Depth
○ Source: B-04	Sample No.: S10	Elev./Depth: 40-41.3'
□ Source: B-05	Sample No.: S7	Elev./Depth: 30-31.5'
△ Source: B-05	Sample No.: S9	Elev./Depth: 40-41.5'

COOPER TESTING LABORATORY

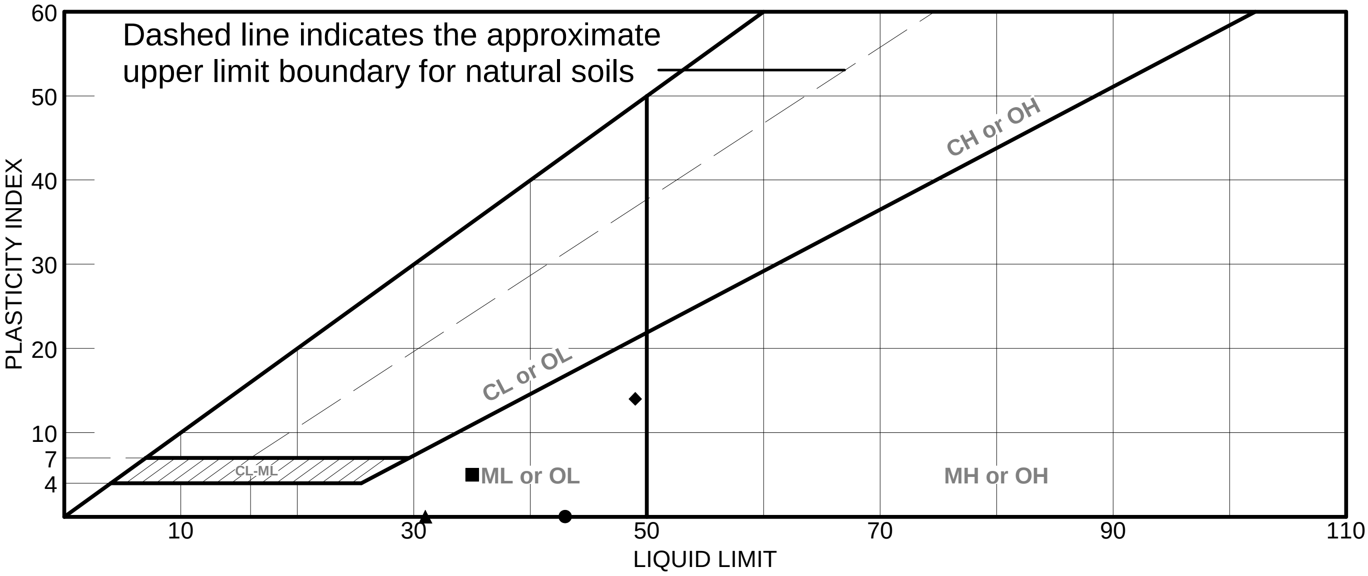
Client: HDR

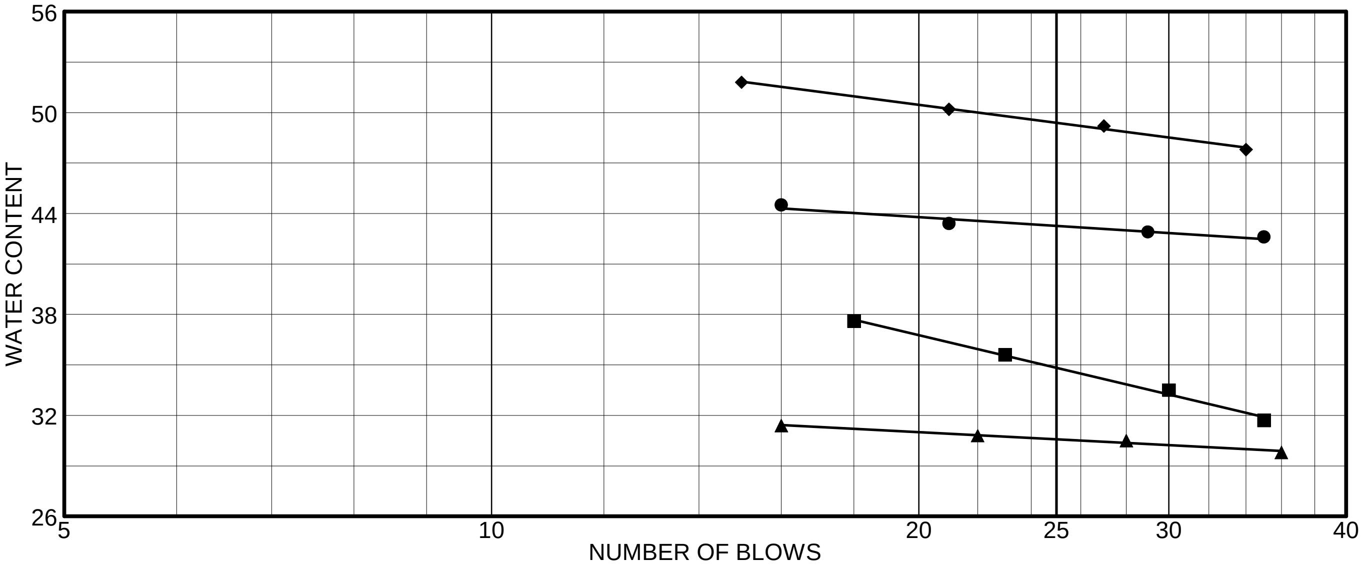
Project: Oroville Wildlife Area - 028-240578

Project No.: 855-011

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Dark Brown Sandy SILT	43	49	NP	80.3	65.2	ML
■	Grayish Brown SILT w/ Sand	35	30	5	96.7	76.7	ML
▲	Grayish Brown SILT w/ Sand	31	35	NP	94.5	81.1	ML
◆	Olive SILT w/ Gravel	49	35	14	88.2	83.8	ML

Project No. 855-011 **Client:** HDR

Project: Oroville Wildlife Area - 028-240578

● **Source:** B-01 **Sample No.:** S8 **Elev./Depth:** 40-41.5'

■ **Source:** B-03 **Sample No.:** S5 **Elev./Depth:** 20-21'

▲ **Source:** B-04 **Sample No.:** S9 **Elev./Depth:** 35-36.5'

◆ **Source:** B-05 **Sample No.:** S12 **Elev./Depth:** 49-49.5'

Remarks:

● Sample was prepared using the wet prep method. Could not roll out. Sample slides in bowl. Non-plastic.

■ Sample was prepared using the wet prep method.

▲ Sample was prepared using the wet prep method. Could not roll out. Sample slides in bowl. Non-plastic.

LIQUID AND PLASTIC LIMITS TEST REPORT

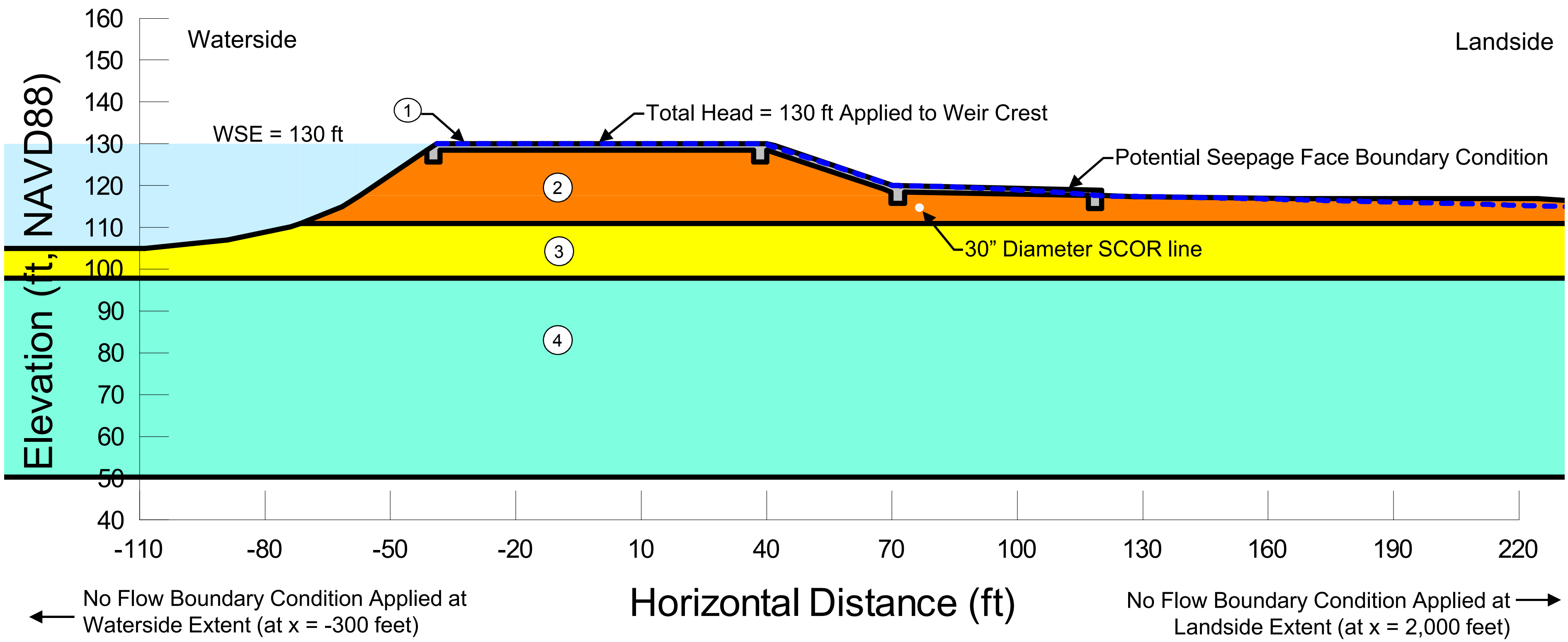
COOPER TESTING LABORATORY

Figure

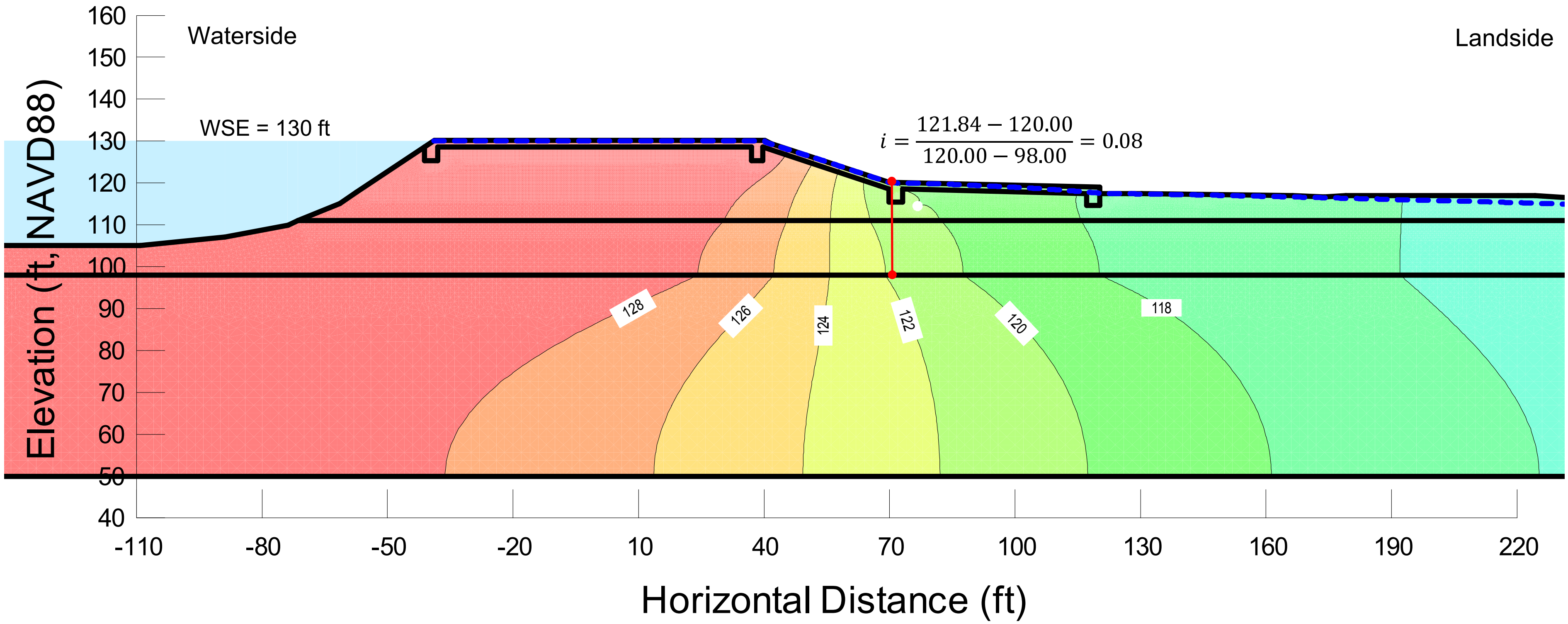
C

Engineering Analysis Results

Layer Number	Layer Name	k_h (cm/sec)	k_v (cm/sec)	k_h/k_v (-)
1	Gabion	1.0E-01	1.0E-01	1
2	GP-GM Levee	2.0E-02	1.0E-02	2
3	SP-SM	8.0E-03	4.0E-03	2
4	ML/SM	6.0E-05	1.5E-06	4



Oroville Wildlife Area	HDR	**Inlet Weir** Steady-State Seepage Model
Butte County, California		January 2016 — Figure C-1



Oroville Wildlife Area

Butte County, California

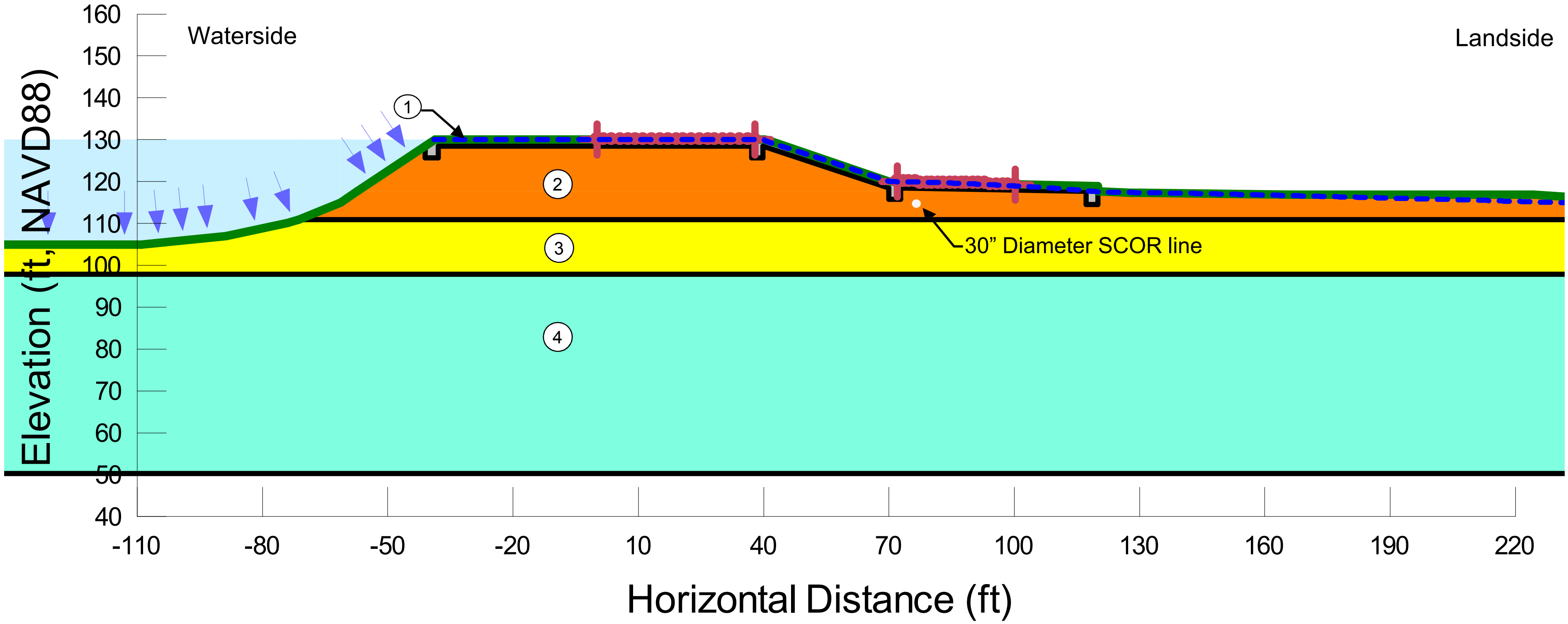
Inlet Weir

Steady-State Seepage Results

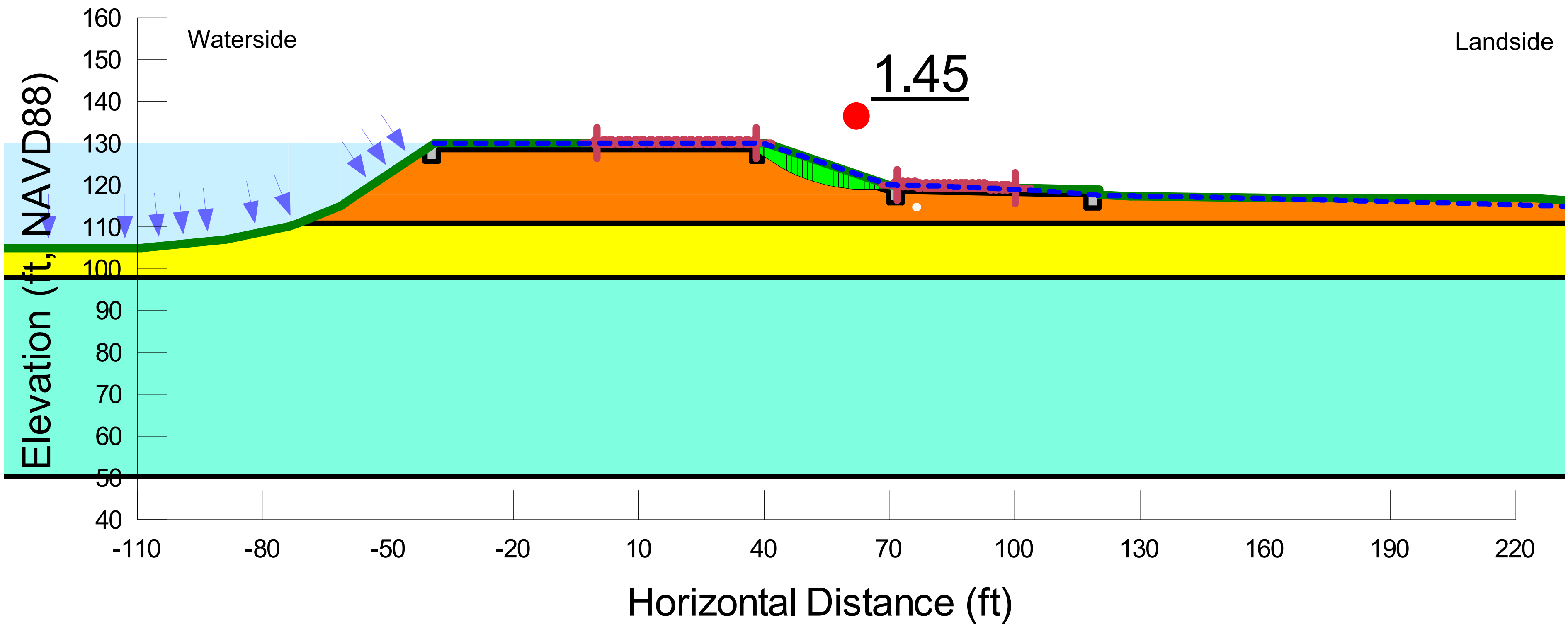
January 2016

Figure C-2

Layer Number	Layer Name	Saturated Unit Weight (pcf)	Drained Parameters c' (psf)	Drained Parameters ϕ' (deg.)
1	Gabion	125	0	40
2	GP-GM Levee	120	0	38
3	SP-SM	120	0	32
4	ML/SM	120	0	30



Oroville Wildlife Area		**Inlet Weir** Landside Stability Model
Butte County, California		January 2016 Figure C-3



Notes:
1. The Factor of Safety (FS) value shown is for the critical failure surface.

Oroville Wildlife Area	HDR	**Inlet Weir** Landside Stability Results
Butte County, California		January 2016 Figure C-4

Appendix D. Riprap Design for Site 2, 5,and 9 Technical Memorandum, February 1, 2016

Riprap Design for Sites 2, 5, and 9

Oroville Wildlife Area Flood Stage Reduction Project

Sutter Butte Flood Control Agency

Oroville Wildlife Area
February 1, 2016

65% Design Submittal

Contents

Figures

Tables

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1 Introduction

The analysis presented in this Technical Memorandum (TM) is part of a larger project for flood stage reduction along the Feather River and restoration of the Oroville Wildlife Area. This document shall be appended to the *Oroville Wildlife Area Flood Stage Reduction Project Basis of Design Report* (BDR)*, which includes* a full description of the project. This TM includes a summary of the analysis, design approach, findings, and recommendation for the riprap components at Project Sites 2, 5, and 9.

2 Site Description

The three sites to be discussed in this document include a four hundred foot inlet weir (Site 2) to provide relief to the Feather River and allow flow into Oroville Wildlife Area (OWA), and outflow weir (Site 5) in the south of the OWA which allows flows in and out of the OWA, and a low flow crossing that will replace an existing culvert (Site 9). Figure 1 shows the location of these sites.

Figure 1. Project Sites Map

3 Summary of Analysis

A Tuflow two dimensional hydraulic model was developed by PBI Consultants to simulate the hydraulic conditions of the project area. A summary of the development of the OWA Tuflow model is included in the *Oroville Wildlife Area Flood Stage Reduction Project Hydraulic Analysis-Baseline Model Documentation* (PBI, August 2015) report. Various baseline conditions were evaluated for the development of the model. Riprap design for Sites 2, 5, and 9 has been sized based upon the 200-year flow conditions. Various design methods were used to size the riprap for the planned site configurations. The Tuflow model was used to develop hydraulic parameters for the various design methods described in the sections below.

3.1 Site 2 – Inlet Weir

Site 2 will function as an overflow weir that allows water from the Feather River into the OWA. The proposed elevation of the weir crest is 130 ft (NAVD88) and the landside slope of the weir embankment is 3:1. The weir is to be lined with gabion mattresses to prevent erosion of the embankment. Design of the gabion mattresses is covered in the *Geotechnical Investigations and Recommendations* TM.

Figure 2. Site 2 - Inlet Weir Location Looking Downstream along the Feather River Levee

Figure 3. Site 2 - Inlet Weir Location looking Downstream at the OWA Side of the Existing Levee

Site 2 was evaluated to determine if additional armoring around the boundaries of the gabion mattresses is warranted.

3.1.1 Calculations

An article published in the *American Society of Agricultural Engineers* journal documented a series of experiments conducted to determine the stable rock sizes for rock chute design (Robinson, Rice, Kadavy 1998). A rock chute is a steep rock-lined channel that serves for slope stability and energy dissipation. An equation was published in this study to determine a stable rock size as a function of unit discharge and slope of the chute. Given the planned Site 2 weir configuration, **Equation 1** was applied to estimate a rock size.

Equation 1 – Stable Rock Size for Rock Chute

$$D_{50} = \left[\frac{\left(qS^{0.58}\right)}{8.07E-6}\right]^{1/1.89}$$

where

q = highest stable unit discharge ($m^3/s/m$)

D_{50} = particle size for which 50% of the sample is finer (mm)

S_o = decimal slope (dimensionless)

If applied at the slope of the weir embankment and given a unit discharge of 98 cfs/ft and a 0.33 slope, it was estimated that a D_{50} rock size of 3.7 ft would be needed for stability.

However, this rock size was deemed too large for boundaries of the gabion mattresses since these edges per the Tuflow results demonstrated reduced flow velocities. Equation 1 was then applied with a unit discharge of 37.6 fps/ft and a 0.03 ft/ft slope to represent the hydraulic characteristics at the boundary of the apron; this resulted in a D_{50} rock size of 0.5 ft. This seemed more reasonable considering velocities in this vicinity were in the range of 7.2 fps or less.

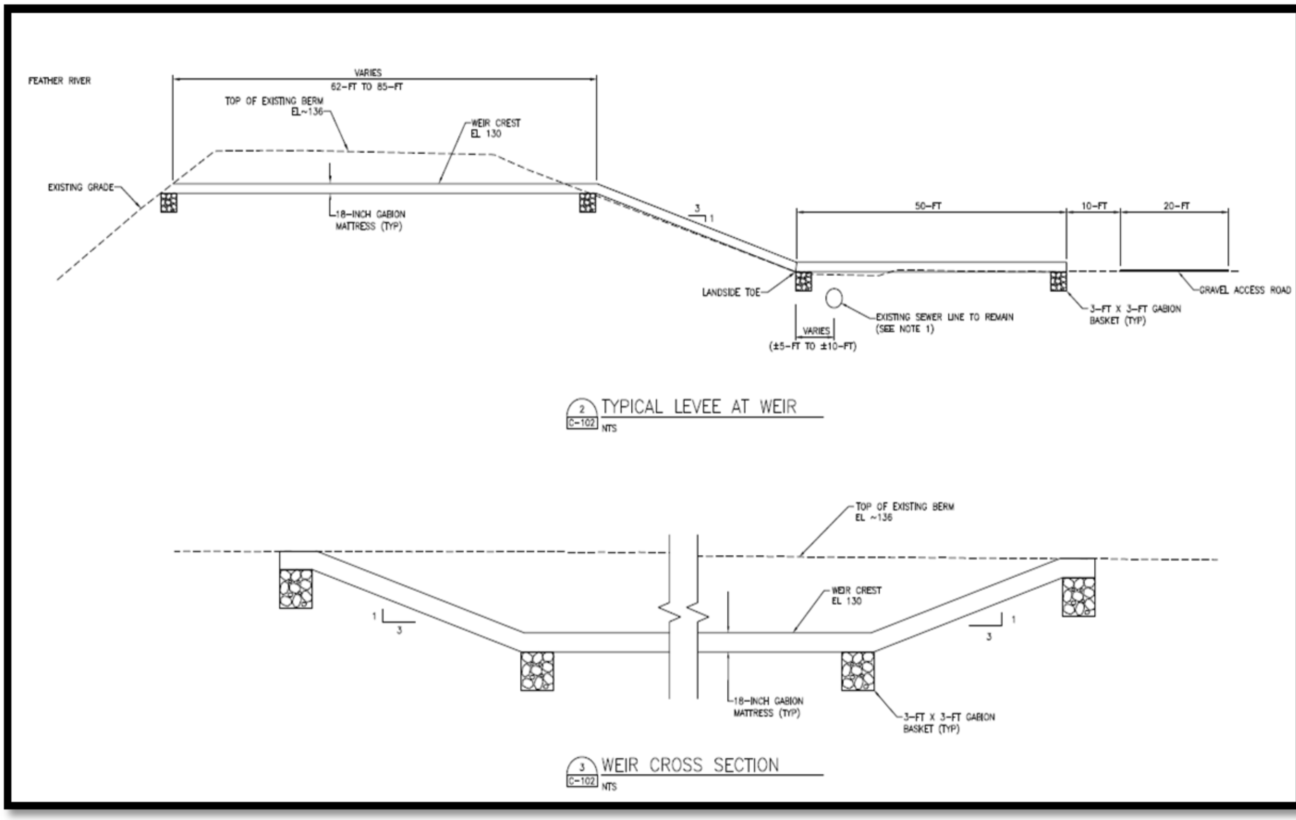
Another equation that was developed as part of the Robinson, Rice, Kadavy experiments was the horizontal distance downstream of the chute at which the primary attack on the riprap would dissipate, Lb (i.e. the required length of horizontal riprap downstream of the sloping section). The recommended value is presented as a function of D_{50} rock size, Lb = 15 D_{50}. Because the D_{50} rock size calculated for the sloping section was 3.7 ft, Lb was calculate to be approximately 56 ft.

3.1.2 Recommendations

Based upon the gabion design and rock chute stable rock size computations, a total gabion mattress length of 60 ft is recommended. The mattress will be buried so that the top of the mattress is aligned with adjacent grade. Likewise, a 60 ft mattress is proposed on both sides of the sloping section of the weir to protect against shear stresses and higher velocities from flows spilling over directly adjacent to the sloping section of the weir. With the extended gabion mattress coverage, additional riprap along the edges is not proposed.

The base native material at Site 2 consists of significant quantities of cobble and gravel. The design proposes to utilize the larger size rocks from this native material to fill the gabion baskets. Therefore, the design assumes that the base material will be self filtering and does not require a separate filter layer. As a point of comparison, a filter layer was not utilized for the existing gabion weir upstream. The weir has been observed as performing well during large flooding events. It has been determined that the base native material is adequate for direct placement of gabion mattresses on top.

Figure 4. Site 2 - Inflow Weir Configuration



3.2 Site 5 – Outlet Weir

Site 5 will function as an overflow weir that allows flow in and out of the OWA and the Feather River. A sheet pile wall with rock armoring on the Feather River side was previously constructed to strengthen the outlet weir and secure the access road. The date of installation of the sheet pile wall is unknown. This sheet pile wall has experienced significant damage during past flooding events, as shown on Figures 6-8. Although rock armoring was placed on the Feather River side of the weir, it seems based on visible damage that rock armoring is also needed on the OWA side to protect the wall from high velocities entering the OWA from the Feather River.

From visual inspection it is estimated that the D_{50} rock size of the existing riprap is 2 ft to 3 ft. Figure 4 shows that the riprap has been displaced and the overall thickness is lacking. In most locations, the thickness consists of only 1 or 2 rocks placed on the natural ground. Overall, this riprap is of high quality and predominately the appropriate size to withstand high velocities coming from both directions; it is the thickness that is lacking. Calculations have been performed to determine appropriate rock size and thickness at the outlet weir below.

Figure 5. Site 5 - Existing Sheet Pile Wall – Feather River Side

Figure 6. Site 5 - Existing Sheet Pile Wall – OWA Side, Existing Access Road

Figure 7. Site 5 - Existing Sheet Pile Wall – Feather River Side, Existing Rock Armoring

3.2.1 Calculations

Rock Sizing

HEC-11 was used to calculate the minimum D_{50} rock size for the proposed revetment at Site 5. **Equation 2** presents the HEC-11 formula based on tractive force theory:

Equation 2 – Stable Rock Size for Rock Chute

$$D_{50} = 0.001\ V_a^3 / (d_{avg}^{0.5}\ K_1^{1.5})$$

where

D_{50} = the median riprap particle size;
C = correction factor (described below);
V_a = the average velocity in the main channel (ft/s (m/s));
d_{avg} = the average flow depth in the main flow channel (ft (m));
K_1 is defined as:

$$K_1 = [1-(\sin^2\theta/\sin^2\phi)]^{0.5}$$

where

θ = the bank angle with the horizontal; and
ϕ = the riprap material's angle of repose.

The following values are applicable to Site 5:

C = NA (Assumed rock SG = 2.65)
V_a = 17.39 ft/sec (maximum value along weir per Tuflow model results)
d_{avg} = 11.6 ft (minimum depth across weir per Tuflow model results)
θ = 18.4° (Assumed per design slope of road embankment)
Φ = 42° (from HEC-11 for large diameter crushed rock)

Maximum velocity and minimum depth values were selected along weir as a conservative design approach. A D_{50} value of 1.87 ft was calculated using Equation 2. For comparison, the rearranged Isbash relationship was also used to verify the minimum D_{50} rock size. The rearranged Isbash formula is presented below:

$$D_{50} = \frac{1}{2}\ \frac{1.384\ V^2}{(s-1)\ 2g}$$

where:
D_{50} = average stone diameter (ft (m))
V = velocity against stone (ft/s (m/s))
s = specific gravity of riprap material
g = 32.2 ft/s^2 (9.81 m/s^2)

The Isbash relationship yields a minimum rock size of 23.63 in. (1.97 ft). When considering typical material and the minimum rock size calculated, it was estimated that ½ ton rock size would be used for the riprap material of Site 5. However, based upon field observations which and an estimated 2.0-3.0 ft D_{50} diameter rock, it is recommended that 1 ton rock material be used for the revetment at Site 5.

Depth of Riprap Revetment

Typical thickness for the recommend riprap mattress range from 1.5 to 2.0 times the D_{50} size of the riprap rock size. Typical 1 ton material is will be used for Site 5. This material has a typical D_{50} of 2.26 ft. A mattress thickness of 5 ft, placed under dry conditions, should be used to meet the recommended dimensions.

Because the water side of the weir is at a slope, it is recommended that riprap mattress is buried with a key at the toe of the revetment. Typically, if scour was observed through field investigations it would be recommended the toe of the riprap revetment be keyed to a depth of 1.2 times the depth of the observed scour. However, no field scour has been observed at this site. In cases where no field scour has been observed Caltrans recommends the following depth:

$$\text{Scour Depth} = D_{mxb} - D_{mnc}$$

Where:

D_{mxb} = maximum water depth at weir (feet)

D_{mnc} = mean channel depth upstream of weir (feet)

Assuming the OWA is the upstream end of the weir, the model yields approximate maximum 200-yr values of D_{mxb} equal to 13 ft and D_{mnc} = 21ft. This results in a scour depth of 8 ft.

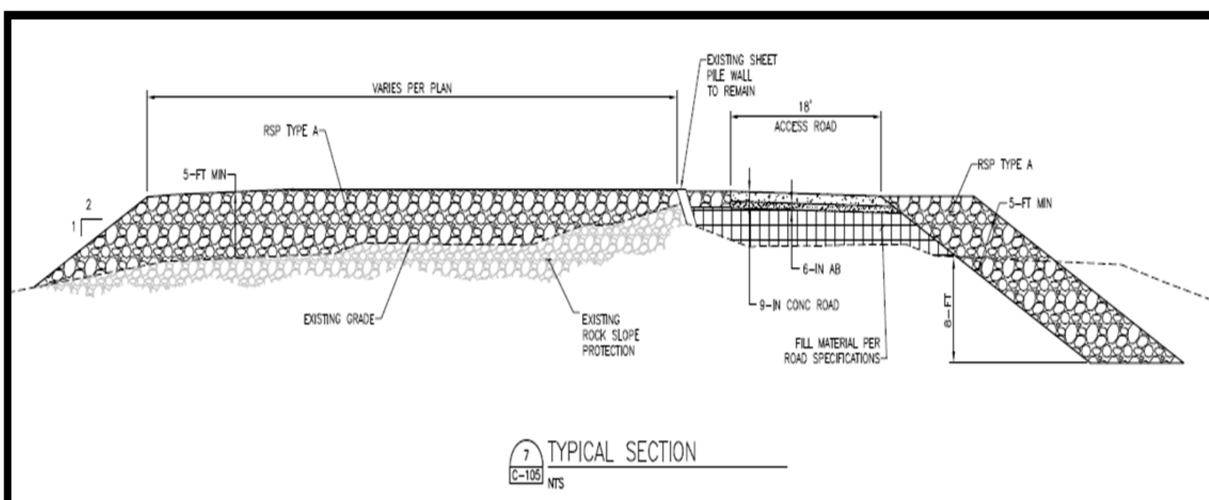
3.2.2 Recommendations

Typical 1 ton rock material will be used for Site 5. The extents of the riprap shall be defined for two different riprap sections along Site 5.

- Waterside of weir - For the revetment along the slope on the Feather River side of the sheet pile weir, it is recommended that the topography be examined for a bench to use as the toe of the revetment. This boundary is indicated in the plans. The revetment blanket should have a minimum thickness of 5 ft.
- OWA side of weir - For the revetment on the OWA side of the road, the revetment shall extend to the edge of the slope. It shall be 5 ft thick and shall include an 8 ft. deep toe key.

Figure 9 shows the preliminary configuration of the sheet pile weir.

Figure 8. Site 5 - Preliminary configuration of the weir including riprap armor



3.3 Site 9 – Low Flow Crossing

Site 9 includes a low flow crossing in the OWA that is to replace an existing culvert. The existing culvert is undersized and has had a history of failure. The planned low flow crossing includes sloping embankments that will experience shear stresses during large flow events. These sloping embankments will be protected with riprap armor.

Figure 9. Site 9 - Existing Culvert Crossing

3.3.1 Calculations

Rock Sizing

The relationship presented in **Equation 2** as described above was used to calculate the minimum D_{50} rock size for the proposed revetment at Site 9.

The following values are applicable to Site 9:

C = NA (Assumed rock SG = 2.65)
V_a = 16.6 ft/sec (maximum value along weir per Tuflow model results)
d_{avg} = 13 ft (minimum depth across weir per Tuflow model results)
$\theta = 18.4^\circ$ (Assumed per design slope of road embankment)
$\Phi = 42^\circ$ (from HEC-11 for large diameter crushed rock)

This relationship yields a minimum D_{50} rock size of 1.54 ft.

Depth of Riprap Revetment

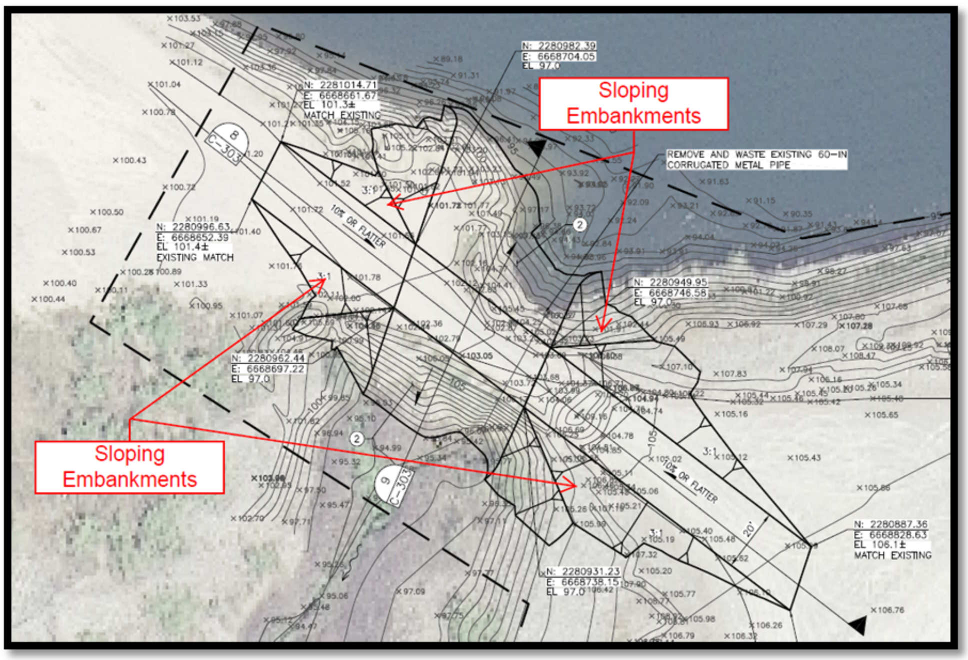
Typical thickness for the recommend riprap mattress range from 1.5 to 2.0 times the D_{50} size of the riprap rock size. When considering typical material and the minimum rock size calculated, it is recommended ¼ ton rock size be used for the riprap material of Site 9. This material has a typical D_{50} of 1.79 ft. A rock thickness of 3 ft should be used to meet the recommended dimensions.

Figure 11 shows the preliminary configuration of the low flow crossing.

3.3.2 Recommendations

Typical ¼ ton rock material will be used for Site 9 with a minimum rock thickness of 3 ft. **Figure 10** shows the preliminary configuration of the low flow crossing.

Figure 10. Site 9 - Preliminary configuration of the low flow crossing



4 Design Recommendations Summary

This section includes a tabular summary of the key riprap revetment specifications for Sites 2, 5, and 9. Armor configurations, placement guidance and details are included in the project plans and specifications.

Table 1 – Key Riprap Revetment Specifications

Location	Proposed Riprap Rock Size	Proposed Minimum Riprap Mattress Thickness (ft)	Key Depth	Notes
Site 2	NA	NA	NA	Gabion mattress with 60 ft apron proposed instead of riprap
Site 5	1-Ton	5 ft	8 ft	Revetment key proposed only for OWA side of road
Site 9	¼ Ton	3 ft	NA	NA

Appendix E. Portable Toilet Foundation Slab Design Technical Memorandum, January 25, 2016

Technical Memorandum

Date:	Monday, January 25, 2016
Project:	Sutter Butte Flood Control Agency
Prepared By:	Adit Joshi P.E.
Reviewed By:	John Houlihan P.E.
Subject:	Portable Toilet (PT) Foundation Slab Design

1 Foundation Slab Dimension

HDR executed the task to design the foundation slab for the PT station located at Oroville Wildlife Area. The requirement was to provide a slab design for permanent installation of PT units for use by the general public. The minimum requirement, based on client discussion, was to provide an ADA (Americans with Disabilities Act) compliant and regular PT for each gender with space for future expansion. Therefore, the slab was designed for two regular and one ADA compliant PT for each gender.

The dimension of a regular PT is 4 ft. wide x 4 ft. long x 7 ft. 8 in. high with the ADA compliant PT at 7 ft. 8 in. wide x 7 ft. 8 in. long x 7 ft. 8 in. high. For wheel chair accessibility, a 5 ft. wide ramp was provided in the front of the ADA compliant PT. For construction and maintenance considerations the PT's are spaced 2 ft. apart. Based of these criteria, the overall slab dimension was 30 ft. long x 22 ft. wide x 1 ft. thick.

1.1 Foundation Slab Design

The design references used for the foundation slab are:

- ACI 318
- ASCE 7-10
- IBC 2009
- Butte County Development Services- Building Division Design Criteria Form No. DCP 5
- AASHTO Bridge Design Manual

The total dead load acting on one half of the slab was assumed to be two regular PT's and one ADA compliant PT. The estimated weights of the regular and ADA PT's when full are 230 and 350 pounds respectively for a total of 810 pounds. The weight of half of the slab would be 150 lbs/cu.ft. x 22 ft. x 15 ft. x 1 ft. = 49,500 lbs It is assumed that a vehicle similar to AASHTO HS 20-44 would be required for installation of PTs. For the design of slab a live load of HS 20 vehicle is considered. A SAP 2000 model was developed to determine maximum moment and maximum shear force from the applied load. As soil data was not available, in order to be conservative a subgrade modulus K = 100 pci was considered. Calculations attached to the report provide detailed information about the slab dimension and reinforcement requirement.

Anchorage of the PT units into the slab was required due to potential wind forces. The basic wind speed of 85 MPH was obtained from Butter County Design Criteria Form No. DCP 5. For anchor design wind load was calculated based on ASCE 7-10. Based on the given information a 1/2 inch diameter post installed threaded inserts with bolts will be used as anchorage for PT units.

It is expected that the top of the slab will be exposed to temperatures ranging from approximately 20 to 100 degrees Fahrenheit. With the potential large temperature differential and the anticipated wheel loadings, the slab was designed with top and bottom reinforcement to withstand these conditions.

The PT units have been placed so that an access road will be no more than 25 feet from the furthest units, to provide for servicing. It is also assumed that the general public will tend to use units closest to the point of access. To ensure that ADA accessible units are available when needed, these units have been located to the rear of the slab.

The slab shall have a minimum 1% cross slope to provide drainage and prevent accumulation of water which might be subject to freezing during cold weather. Final grading is recommended to provide positive drainage away from the concrete slab.

The wind, anchorage and concrete slab design calculations are attached herein. The drawing details will be provided in sheet C-101 of 60 % OWA plan sheets.

Project:	Sutter Butte Flood Control Agency	Computed:	ARJ	Date:	8/21
Subject:	Portable Toilet slab	Checked:		Date:	
Task:	Slab on Grade Design	Page:	1	of:	
Job #:	249578	No:			

SLAB LOADING

Live load of HS-20 Truck is considered as worst load. For slab design.

Load factors (strength I, Load combination AASHTO 4th ed.)

1. Dynamic load Allowance = 1.33
2. Live load = 1.75

HS-20 Wheel loading = 16 k/wheel

Total load = $16 \times 1.33 \times 1.75 = 37.24$ kip

Max: Moment = 8.04 kip-in/in
$= 8.04 \times 12$ kip-in/ft
$= 96.48$ kip-in/ft.

$\therefore M_u = 96.48$ kip-in/ft.

Depth of slab = 12 in
Clear cover = 3 in
#5 diameter = 0.625 in.
Effective depth $= 12 - 3 - \frac{0.625}{2} = 8.68$ in

$$\frac{M_u}{\phi b d^2} = \frac{96480 \text{ lb-in}}{0.9 \times 12 \times 8.68^2}$$

$$R_n = \frac{M_u}{\phi b d^2} = 118.56 \text{ psi}$$

$$\rho = \frac{0.85 \times 4000}{60{,}000}\left(1 - \sqrt{1 - \frac{2 \times 118.56}{0.85 \times 4000}}\right)$$

$$\rho = 2.011 \times 10^{-3}$$

$A_s = \rho bd$

$= 2.011 \times 10^{-3} \times 12in \times 8.68 in$

$= 0.209 \; in^2$

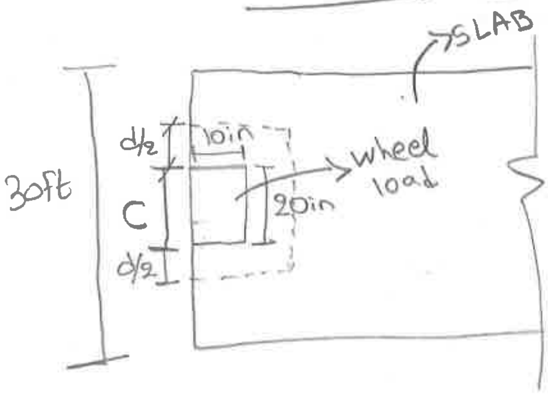
$A_s \times 1.33 = 0.209 \times 1.33 = 0.27 \; in^2$

As per ACI section 10.5.3, $A_{s,min} = \frac{3\sqrt{f_c'}}{f_y} b_w d$ or $\frac{200 b_w d}{f_y}$, need not apply, if Provided As is 33% greater then require As.

Provde #5 @ 12 in T & B Each way.

SLAB DIMENSIONS: 30ft x 22ft x 1ft

Design For Punching Shear



$c = 20$ in

$d = 12$ in (depth of slab)

Length of critical Perimeter

$b_o = (c+d) + 2(c + d/2)$

$b_o = (20+12) + 2(20 + 12/2)$

$= 32 + 52$

$= 84$ in

According to ACI sec 11.11.2.1

$\phi V_c = 4 \phi d b_o \lambda \sqrt{f_c'}$

$= 4 \times 0.75 \times 12 \times 84 \times 1 \times \sqrt{4000}$

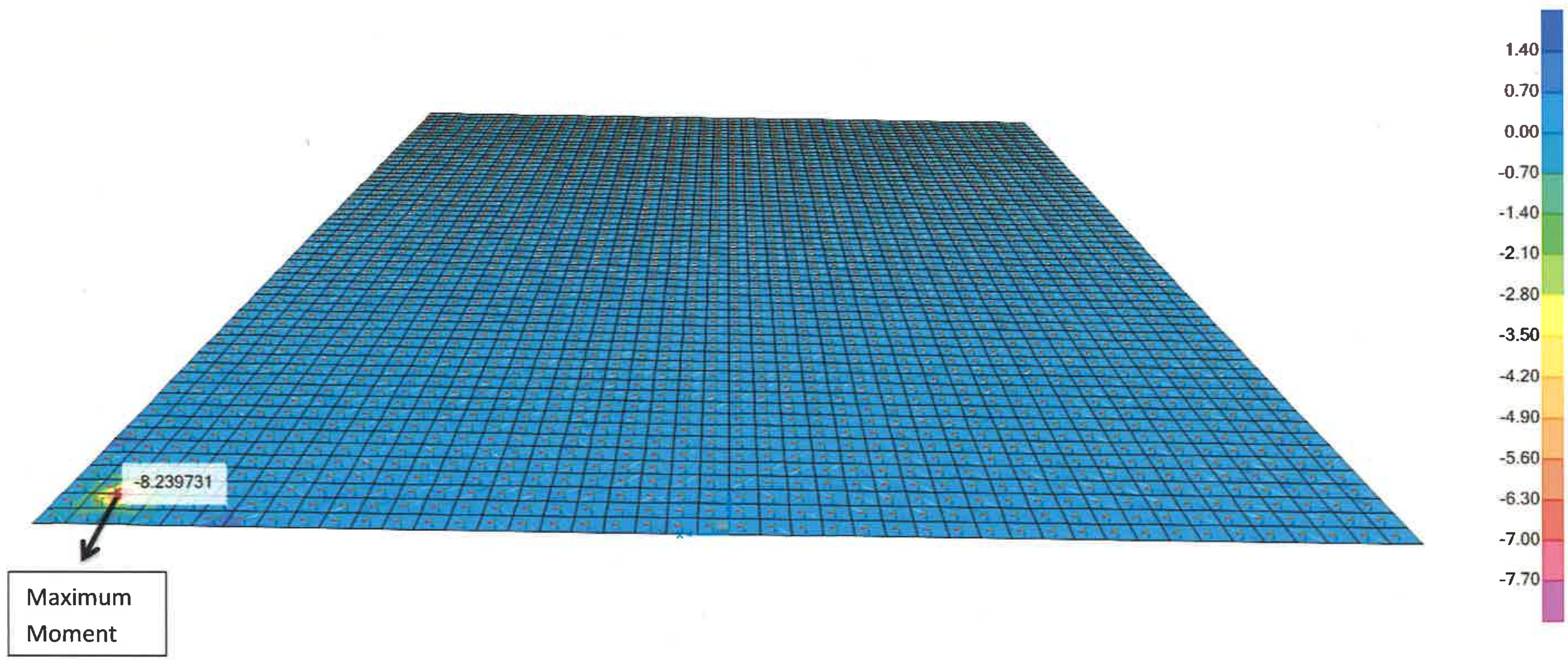
$\phi V_c = 191.254$ kip

$V_u = 2.1$ kip (From SAP MODEL)

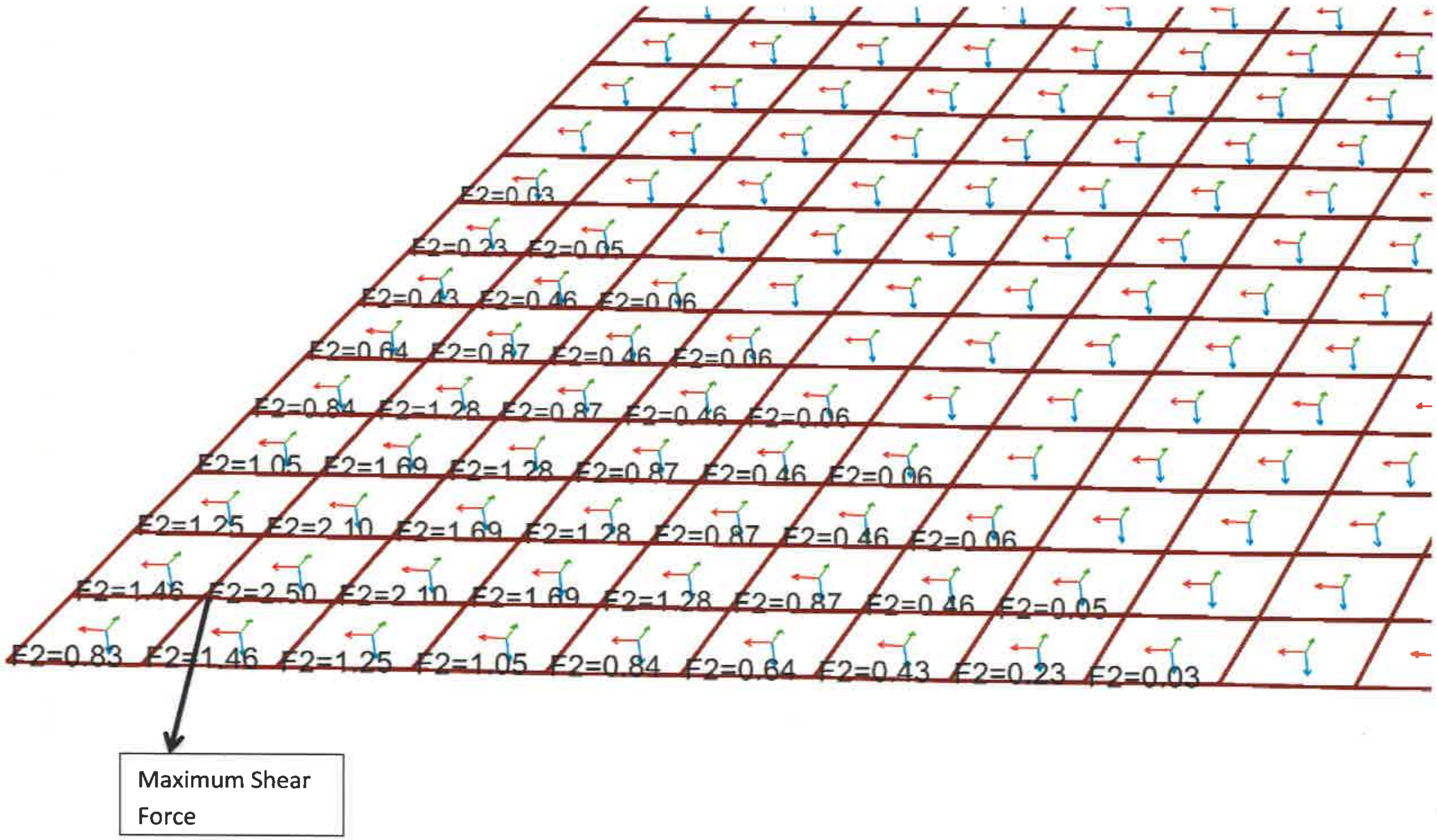
∴ Satisfactory

Sutter Butte Flood Control Slab on Grade Design: SAP 2000 Model for determining Maximum Moment and Maximum Shear

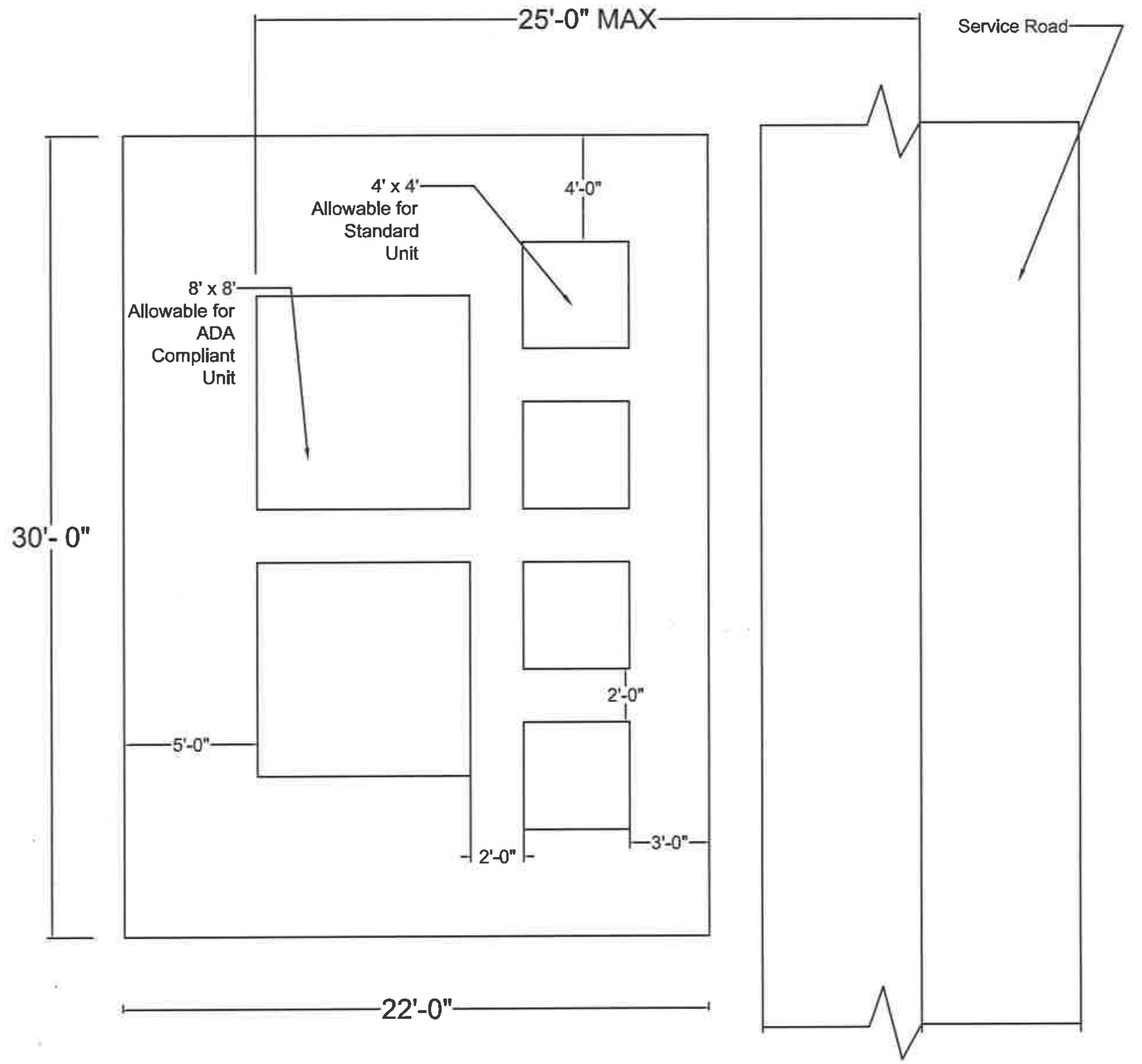
Fig. 1- Maximum Moment = 8.23 Kip-in/in

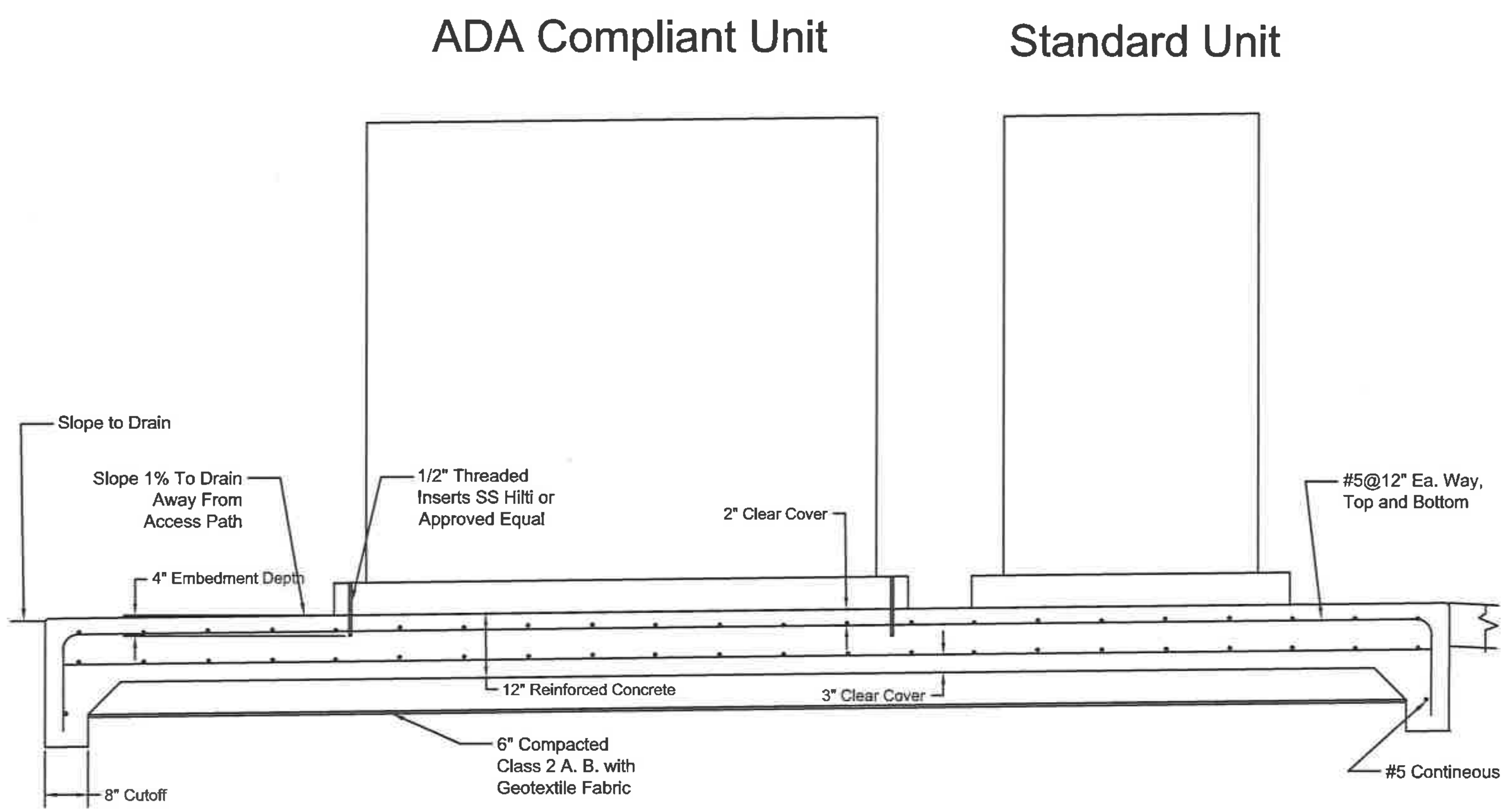


<u>Fig. 2</u>- Maximum Shear force = 2.50 Kip



SLAB- PLAN


25'-0" MAX
Service Road
4' x 4'
Allowable for
Standard
Unit
4'-0"
8' x 8'
Allowable for
ADA
Compliant
Unit
30'- 0"
2'-0"
5'-0"
2'-0"
3'-0"
22'-0"


ADA Compliant Unit
Standard Unit
Slope to Drain
Slope 1% To Drain Away From Access Path
4" Embedment Depth
1/2" Threaded Inserts SS Hilti or Approved Equal
2" Clear Cover
#5@12" Ea. Way, Top and Bottom
12" Reinforced Concrete
3" Clear Cover
6" Compacted Class 2 A. B. with Geotextile Fabric
#5 Contineous
8" Cutoff

Standard Portable Toilet w/ Urinal

Enclosed unit with a door that can be locked from the inside, approx. 4' wide x 4' deep x 7.5' high, made from injection molded plastic. Has 1 toilet seat over a 50 – 60 gal holding tank which contains approx. 5 gal of liquid chemical for breaking down waste. Usually stocked with seat covers, toilet paper and waterless hand cleaner. Requires placement where truck can approach to within 25' for servicing. The Tufway unit is manufactured by Satellite Industries – Port-O-Let Height: 88" Width: 44" Depth: 48" Weight: 230 lbs.

ADA Compliant Portable Toilet

Complies with Americans with Disabilities Act standards. Dimensions are 7'-8' wide x 7'-8' long by 7'-8' high. Constructed of reinforced injection molded plastic. Spring loaded magnetic door closes automatically. Wheelchair accessible with grab bars. Interior space allows wheelchair to turn 360 degrees. Single toilet seat over 50 – 60 gal holding tank containing liquid chemical for breaking down waste. Usually stocked with seat covers, waterless hand sanitizer, and toilet paper. NOTE | Once a sink is placed inside of a 7'-8' ADA restroom, the unit ceases to conform with the American with Disabilities standards. It maintains the status of a handicap - accessible toilet and bathroom. The Freedom 2 unit is manufactured by Satellite Industries – Port O Let Height: 90.75" Width: 77" Depth: 77" Weight: 350 lbs. Optional Tank of 35 gallons is available to meet California Title 24.

Project:	Computed:	Date:
Subject:	Checked:	Date:
Task:	Page: 9	of:
Job #:	No: 2	

Wind Load Calc.

Basic Wind Speed = 100 MPH (Butte County Design Criteria, Form No DPC 5)

Risk Category = I (Table 1.5-1 - ASCE 7-10)

Wind Directionality Factor $K_d = 0.9$ (Chimney, Tanks or similar, square) Table 26-6-1 ASCE 7-10

Exposure Category = C (Section 26.7.3 ASCE 7-10)

Topographic Factor K_{zt}

$K_{zt} = 1$ (Section 26.8.2 ASCE 7-10)

Gust Factor $G = 0.85$ (Section 26.9.1 ASCE 7-10)

Enclosure Classification - Structure is Enclosed Full height.

Internal Pressure Coefficient (GC_{pi})

Enclosed Buildings +0.18
-0.18

Determine Velocity or Pressure Exposure Coefficient
K_z or K_h

Height of Porter Potty = 7'-8"
Exposure C = 0.85

$Z = 7'\text{-}8" < 15'$
$\therefore K_z = 2.01\,(15/Z_g)^{2/\alpha}$

From Table 26.9.1 (ASCE 7-10)
For Exposure Category C
$\alpha = 9.5 \quad Z_g = 900$

$K_z = 2.01\,(15/900)^{2/9.5}$

$K_z = 0.848 \approx 0.85$

Velocity Pressure (Section 27.3.2 ASCE 7-10)

$q_z = 0.00256\,K_z\,K_{zt}\,K_d\,V^2$

$q_z = 0.00256 \times 0.85 \times 1 \times 0.9 \times 100^2$

$q_z = 19.58\ \text{lb/ft}^2$

Project:	Computed:	Date:
Subject:	Checked:	Date:
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Wall Pressure Coefficent, Cp Figure 27.4-1 (ASCE7-10)

$C_p = 0.8$ (Windward wall)

$C_p = -0.9, -0.18$ Roof.

Wind Pressure

$P = q G C_p - q_i (G C_{pi})$ section 27.4-1

$P = 19.58 \times 0.85 \times 0.8 - 19.58 (-0.18)$

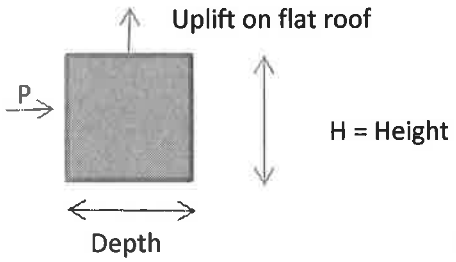
$h = z$ (Flat roof)

$P = 16.83 \text{ lb/ft}^2$

Use 16.83 lb/ft^2

Wind Load Calculation

Checking for uplift due to horizontal wind load



Min. wind pressure = **16.83** psf

	H (ft)	W (ft)	HxW (sf)	P (lb) = HxWx16.83 psf	M= P(H/2)	D ft	Uplift/anchor = M/(Dx2)
ADA	7.67	7.67	58.83	990.09	3797.00	7.67	247.52 lb
Standard	7.50	4.00	30.00	504.90	1893.38	4.00	236.67 lb

Checking for uplift on flat roof

	W (ft)	D(ft)	Roof Area (SF)	Uplift (lb)	Uplift/anchor
ADA	7.67	7.67	58.83	990.09	247.52 lb
Standard	4.00	4.00	16.00	269.28	67.32 lb

	Horiz wind load(lb)	Roof uplift (lb)	Total (lb)
Max Uplift on windward anchors			
ADA	247.52	247.52	495.05
Standard	236.67	67.32	303.99
Max. Uplift on leeward anchors			
ADA	-247.52	247.52	0.00
Standard	-236.67	67.32	-169.35

Verifies that ADA compliant unit is worst case

Max. Service Loads (to windward anchors on ADA compliant unit)

Wind load (W) 495.05 lb tension

Dead load (D) = 350.00 lb / 4 = 87.50 lb compression

Max. Design Factored Load = 1.6 W - 0.9D =

(1.6 x495.05)-(0.9x87.50) = **713.32** lb./anchor

Project:	Computed:	Date:
Subject:	Checked:	Date:
Task:	Page: 13	of:
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Anchorage of Portable Toilet to slab:

Assumption

section is cracked.

Total load per bolt = 713.32 lb/anchor.

Basic breakout strength for single anchor per ACI 318 D 5.2.2

$$N_b = k\,(F'_c{}^{0.5})\,h_{ef}^{1.5}$$

$$k = 17\,(4000)^{0.5} \times 4^{1.5}$$

$h_{ef} = 4$ (Embedment depth)

$$N_b = 8601.39\text{ lb} > 713.32\text{ lb}$$

Edge distance is > $1.5 \times h_{ef}$.

Bond strength per Hilti = 615 psi for 1/2" rod in cracked area

Bond area = $\pi \times 0.5 \times 4\text{ in} = 6.28\text{ in}^2$

$$615 \times 6.28 = 3862.2\text{ lbs} > 713.32\text{ lb.}$$

Use 1/2" threaded SS insert with 4" embedment length.

Note: The anchorage is designed for Concrete to anchor connection. It is not designed for connection between the bolt and Portable toilet.

It is contractor's responsibility to select appropriate Portable toilet material that can withstand designed wind load provided in this calculation.

Appendix F. Summary of Quantities

SUTTER BUTTE FLOOD CONTROL AGENCY
CONTRACT NO.

OROVILLE WILDLIFE AREA (OWA) FLOOD STAGE REDUCTION PROJECT
ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST
65% Submittal - Estimate of Quantities

OROVILLE WILDLIFE AREA D-UNIT					
Line Item No.	**Item Description**	**Estimated Quantity**	**Unit**	**Unit Price ($)**	**Total Price ($)**
1	Mobilization and Demobilization	1	LS		
2	Traffic Control	1	LS		
3	Storm Water Pollution Control	1	LS		
4	Project Fencing	11,800	LF		
5	Clearing and Grubbing	1	LS		
6	Top Soil Stripping	15,000	CY		
7	Remove and Dispose - 60 Inch Pipe	2	EA		
8	Excavation	20,000	CY		
9	Engineered Fill	9,600	CY		
10	Class 2 Aggregate Base	3,600	TN		
11	Concrete Road	500	CY		
12	Concrete Pad	1	LS		
13	Gabion Basket and Mattress	5,200	CY		
14	RSP Type A Material	13,800	TN		
15	RSP Type B Material	1,700	TN		
16	24 Inch Corrugated Metal Pipe	40	LF		
17	72 Inch Corrugated Metal Pipe	259	LF		
18	Boulders	825	LF		
19	Erosion Control Seeding (Site)	4	AC		
20	Haul and Waste (Unsuitable Material)	1,000	CY		
				TOTAL:	